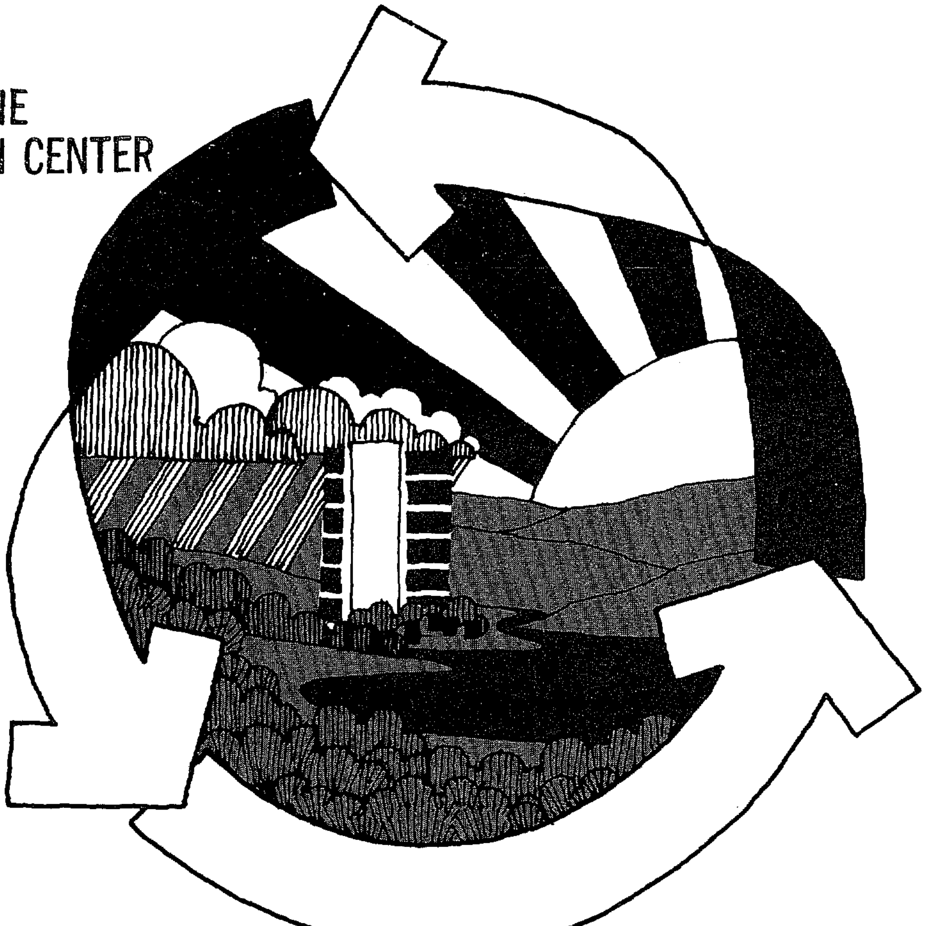

Stormwater Management Alternatives

J. Toby Tourbier
Richard Westmacott,
Editors

UNIVERSITY OF DELAWARE WATER RESOURCES CENTER

15075

Stormwater Management Alternatives

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NEWARK, DELAWARE
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June 16, 1980

Dallas Miner
Office of Coastal Zone Management
3300 Whitehaven Street, NW
Washington, DC 20235

Dear ~~Mr. Miner~~ Dallas:

Enclosed is your complementary copy of "Stormwater Management Alternatives," the Proceedings from the National Conference held on October 3-5, 1979. We hope the quality of printing will make up for the long delay in production. Extra copies of this publication can be purchaced for $15.00 from the Water Resources Center.

Thank you again for your participation in this Conference.

Sincerely yours,

Toby

J. Toby Tourbier
Project Director

JT/sjp

Enclosure

Stormwater Management Alternatives

J. Toby Tourbier and
Richard Westmacott, Editors

Water Resources Center
University of Delaware
Newark, Delaware 19711

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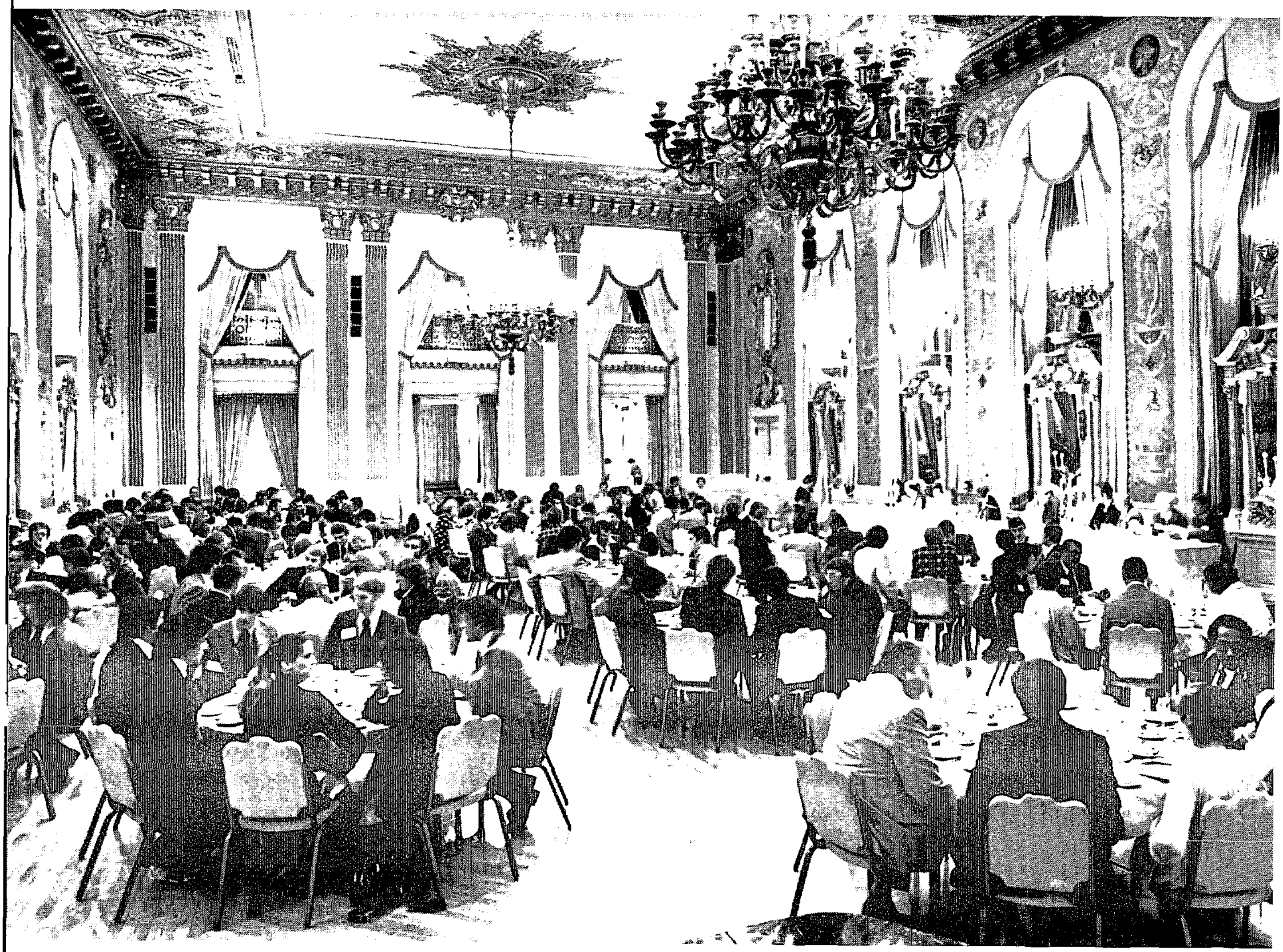

An address by Senator Edmund S. Muskie brought together conferees and interested citizens in the Gold Ballroom of the Hotel du Pont.

INTRODUCTION

The conference on Stormwater Management Alternatives had its origin in a contract with the Office of Water Research and Technology of the U.S. Department of the Interior, under which the editors (1) investigated water resources protection technology and produced a handbook of measures to protect water resources in land development. This handbook is recommended reading of Section 208 "Guidelines for Areawide Waste Treatment Management Planning," and its specifications sheets for the construction of physical improvements have been copied in many reports, most notably by agencies concerned with implementing "Best Management Practices" under the Clean Water Act. Other reasons for the popularity of the handbook are its comprehendability by potential users, and its design guidelines and outline specifications for the construction of physical improvements that can be functional and enhance a site.

Stormwater management remains to be a national problem. Flood losses are increasing in spite of ever-rising expenditures for flood control. Non-point sources of stormwater pollution from urban areas are the major source of water pollution in many areas. Most urban streams today are neglected and often a sensual blight, even though more money has been spent (since 1972) to clean up the nation's waters than to construct the nation's highway network. Opportunities for multi-use planning are often ignored. Blue-green technology can incorporate flood control, stormwater pollution abatement, recreation, and comprehensive city planning and development. Stormwater management technology can be convivial (implying *conviviere* - with life) resulting in a product that can be lasting, functional and beautiful. This concept inspired an educational color poster that was produced by the editors (see page 19) and announced the conference through a special feature article in a professional journal (2). In addition, 2500 copies of a first announcement and call for papers were mailed announcing "Blue-Green Technology - STORMWATER MANAGEMENT ALTERNATIVES - Turn a Liability into an Asset." The announcement invited authors to offer papers on the following topics:

1. NON-STRUCTURAL CONTROLS - to prevent stormwater problems at their source. An example is the prevention of runoff increases and inducement of ground water recharge through land use allocations, and the prevention of stormwater pollution through surface sanitation and chemical use control, erosion control and open space protection in ecologically critical areas.

2. STRUCTURAL CONTROLS - to delay runoff, reduce flood damage, trap sediment, protect stream channels and banks.

3. BEST MANAGEMENT PRACTICES - a rationale for evaluating methods in regard to (a) their cost effectiveness in avoiding or minimizing water problems, and (b) their sensitivity to social and cultural values.

4. DESIGN FOR MULTIPURPOSE USES - can take the form of "Blue-Green" development or "Greenways" that offer recreation opportunities, establish open space buffers, increase property values, protect cultural resources and enhance aesthetic values.

5. FUNDABILITY AND INSTITUTIONAL ARRANGEMENTS - are the lifeline for public projects. Flooding and stormwater pollution is the responsibility of different federal agencies. New and comprehensive stormwater management laws are now being passed by many states.

6. PUBLIC INFORMATION/PARTICIPATION AND LOCAL SUPPORT - is essential for the implementation of projects. Public information and constituency building is an important prerequisite for a meaningful public participation in decision making.

The Federal Clean Water Act represents a national commitment to making the nation's surface water resources fit for fishing and swimming by 1983. A strong supporter of this was former Governor of Delaware and former U.S. Senator J. Caleb Boggs, who served as the chairman of the planning committee for the Stormwater Management Alternatives Conference. It was upon his invitation that Senator Edmund S. Muskie agreed to be the keynote speaker of the three-day event on October 3, 4 and 5, 1979. The conference was held at the Hotel du Pont in Wilmington, Delaware close to the banks of the Brandywine River. The Brandywine and the Christina River Basins (3) have a long history of water resources concern in planning. The Brandywine has long been considered a potential model river (4). The conference included a field trip in a Wilmington and Western Railroad vintage train along the banks of the river, with a stop at the Brandywine River Museum to view land management practices and an exhibit of the Brandywine School of Painting. The conference was attended by over 300 people who shared an interest in stormwater management practices that are desirable alternatives to the conventional. Through blue-green technology stormwater becomes a resource that can be managed to enhance a community and make it a more livable place -- today and in the future.

J. Toby Tourbier
Technical Program Director

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ACKNOWLEDGMENTS

Most papers in this report were presented at the Stormwater Management Alternatives Conference, which was supported by seed money from the Office of Water Research and Technology of the U.S. Department of the Interior and funded by the U.S. Environmental Protection Agency, Region III.

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Special acknowledgment is given to the moderators of the sessions: Mr. Peter A. Larson of the Greater Wilmington Development Council, Mr. Boyd C. Steed, School of Environmental Design, University of Georgia and Mr. Warren O'Sullivan, New Castle County Department of Public Works. A reception and exhibit in Willingtown Square was made possible by cooperation from The Historical Society of Delaware, and by contributions from Rollins Environmental Services, Inc., Leon N. Weiner and Associates, Inc., and E. Earle Downing, Inc., all of Wilmington, Delaware.

Our grateful thanks also to Ms. Dana Anderson and Charles Goedken for invaluable staff work before, during and after the conference.

Guidance and support from many distinguished and knowledgeable persons in the District of Columbia and the States of Pennsylvania and Delaware greatly facilitated management of the Conference. The Conference also enjoyed a gratifying response from leading speakers and authors in the Stormwater Management field, as evidenced by this publication.

Again, thanks to all.

J Caleb Boggs

J. Caleb Boggs
Chairman, Conference
Advisory Committee

April 1980
Wilmington, Delaware

I. A RATIONALE FOR INNOVATIVE AND ALTERNATIVE STORMWATER MANAGEMENT

Senator Edmund S. Muskie addressing the National Conference on Stormwater Management Alternatives

1

REMARKS AT THE NATIONAL CONFERENCE ON STORMWATER MANAGEMENT ALTERNATIVES, WILMINGTON, DELAWARE, OCTOBER 4, 1979

SENATOR EDMUND S. MUSKIE

Democrat (Maine)

When I speak to a conference like this, I often wish you were giving the speeches and I were the audience.

As a wise man once told me, "When you're talking, you ain't learning much." And there is a great deal all of us who help make policy in Washington need to learn about stormwater runoff and other non-point pollution problems.

Non-point pollution is without question our most intractable environmental challenge.

There was a time when we looked forward to the splendid relief of rain. Now, especially in the northeast, we are learning that rain can also bring acids that kill our fish and stunt our trees and crops.

There was a time when the amazing ingenuity of modern chemists held the promise of a future of limitless bounty. Now some of us have discovered that our homes are dangerously close to, or on top of, buried chemical poisons.

There was a time when we thought pesticides would produce only superior crop yields and not "superbugs."

As the costs and risks of pollution became known, we undertook an accounting. We set a course aimed at cleaning up our past errors and preventing new pollution mistakes. We have made some progress in that effort.

But the chief accomplishment of a decade of environmental cleanup has been to expose the staggering depth and complexity of the problems which remain. One is non-point sources of water pollution. A second is the discharge of chemical poisons and other hazardous wastes. A third is the global nature of air pollution and the threat from carbon dioxide generated by fossil fuel use.

We have abundant evidence that the road ahead is longer, steeper and more poorly mapped than the road behind.

We, in this room, are dedicated to traveling that road. We understand the complexity of the problem, the need for better research, better financing, and more effective methods. We think the problem can be alleviated, but we don't know the size of the task.

For example, the ultimate solution to urban wastewater problems certainly lies in a fundamental change in the way our society lives, works and travels.

Studies done in Washington, D.C., have shown that some of the major sources of pollution in stormwater are litter, construction debris and automobile-related chemicals and solids.

The ultimate solution to a pollution problem is to remove the source, as we all know. In the case of Washington, that would mean removing the people, the progress and the private automobile; or changing social values developed and nurtured in a half-century of material progress.

The first course is neither politically, practically nor morally possible for those of us who believe environmental policy must accomodate man <u>and</u> his environment. The second will take time -- a great deal of time.

Congress knew when it passed the Clean Water Act in 1972 that the number and diversity of discharges from non-point sources would be overwhelming and that they could not be subjected to the same type of regulatory mechanism established for communities and industries.

We knew that the runoff from agriculture, construction, surface stormwater, underground mines and other non-point sources would require local management and regulation -- rather than the application of a certain type of technology at the end of a pipe.

I don't think we quite knew the complexity -- the political, social, environmental, and engineering hurdles we would have to jump in order to achieve our goals. We still know far too little about the problem.

The Environmental Protection Agency is taking some concrete steps to better define the problems of non-point pollution and test some of the possible solutions.

-- In conjunction with the U.S. Department of Agriculture, EPA plans to carry out a program of water quality management in seven different areas around the country in order to provide better information about the non-point problems.

-- EPA has initiated the Nationwide Urban Runoff Program and is working with the U.S. Geological Survey to establish an up-to-date and accessible data base on the various urban watershed problems and management methods.

Thirty studies will be conducted nationwide in order to cover a wide range of varying climatic regions.

But, most important, studies like these aim to establish critical links at the local level between planning and implementation of management programs.

This conference is another valuable means of exploring the problem and considering solutions. You are discussing structural and non-structural controls; the so-called "Blue and Green Development" designs for multi-purpose use; and some of the best management practices.

And you are discussing ways to increase public awareness of the problem and public acceptance of the treatment.

The Clean Water Act recognizes local political support as a key ingredient in the process.

The Section 208 Program has experimented with voluntary controls and has allowed states to develop their own regulations to suit their regional needs.

Some have criticized a policy that allows so much local discretion. And it is true that some management agreements have taken advantage of the volunteer nature of the law and some local government entities have not utilized 208 monies in the best possible manner.

But I regard 208 as a test of the capacity of the partnership among federal, state and local governments. I hope it will demonstrate to Washington whether or not localities and states are capable of planning and regulating environmental management problems on their own.

It is a test to see if the pesticides carried by stormwater and other non-point means in the San Joaquin Valley in California can be controlled locally.

It is a test to see if the Potomac River can be truly clean for swimming again because of local decision-making.

If it doesn't work -- if all the good reasons for allowing local control on non-point pollution programs fail to establish concrete results -- a signal will be sent that the present program needs substantial revision.

As far as I am concerned, the verdict is still out as to whether or not new regulatory authority is needed. But I want the local programs to work.

I want regions to deal with problems effectively -- and in the manner that regional characteristics dictate.

The public participation embodied in the 208 Program can be an effective tool.

And in my judgment, it must be made to work.

I say "must" because in my judgment there is not sufficient political support for an environmentally responsible alternative if the 208 Program fails.

This conference was called to explore alternatives. There is at least one alternative -- seriously proposed by powerful and sincere men and women in Washington and around the country -- which you are not considering. That alternative is to do nothing. Some of those people want us to declare victory against air and water pollution and scale back our goals. Others who have supported federal programs in the past are asking whether we can continue to afford massive spending in a time budgetary restraint.

And by all accounts, staggering amounts of money will be needed to do the cleanup job completely.

Yet even the existing water pollution construction grant program is under attack.

In the last year we have seen a reduced Presidential budget request. We have seen a proposal by the House Appropriations Committee's investigation staff for zero funds for the 1980 fiscal year. We have seen an attempt in the Senate Budget Committee to cut one billion dollars from the program -- a cut that was restored only after a major struggle.

We supporters of environmental progress increasingly are going to find ourselves expending precious political capital to protect even the modest gains we have made. Programs to solve the tougher problems may be beyond our reach.

Those of you who think this is an overly pessimistic assessment need look no farther than the Senate's votes this week on the energy mobilization board.

The Senate Energy Committee wrote a bill which in my judgment brushed aside not only environmental considerations, but due process, state's rights and political accountability.

An alternative which Senator Ribicoff of Connecticut and I offered was defeated by 20 votes. An amendment aimed at moderating the most foolish and dangerous portions of the committee bill passed only after a considerable struggle.

The Senate Energy Committee wrote a bill which would leave workers at an experimental energy plant defenseless against unforeseen poisons created there; a bill which would leave the people nearby vulnerable to poisonous discharges; a bill which would leave the environment near and far open to unimaginable degradation. And the government would be allowed -- by law -- to stand by and let it all happen.

Our energy problems are serious, and our need for a remedy is apparent. The motivation of senators may have been fear or haste or a determination to do anything, even the wrong thing, in the name of energy independence. But regardless of the motive, the message was clear: This country's political leaders can be persuaded to cast aside environmental law in the name of energy, or budgetary prudence, or jobs or fighting inflation.

I do not find the same attitude among the people I talk with. The average citizen feels just as strongly today as ten years ago that the environment is worth preserving, that our resources of air and water are just as precious as our oil. But his message is not being delivered often enough or effectively enough.

Organized environmental groups seem as interested in attacking their allies as their enemies. Political organizations are not being used as effectively as they could be for environmental purposes or any other.

And the forces allied on the other side are well-organized, well-heeled and well-prepared.

Unless we are prepared to rejustify the programs now on the books, and make iron-clad arguments in behalf of new initiatives, we will not win. It is that simple.

I do not believe the environmental movement in this country can afford to slip into a comfortable middle age. For sound environmental policy to survive, it must retain the capacity to improve and reshape itself as new information is received. We must also demand that environmental programs produce the greatest environmental benefit possible for the least amount of money. It must keep its facts at hand and its powers of persuasion sharp. Most importantly, it must make no assumptions that rights affirmed and programs won are safe from attack. Those who have participated in the monumental struggles over clean air law ought to know better. Those who care about our water resources should examine that debate and be warned.

I hope you will not confuse my assessment with my resolve. I do think we can continue to make environmental progress in this country. I am certain we must. The very air we seek to conserve is just as crucial an ingredient to combustion as the oil we pump from the ground or squeeze from a lump of coal.

But you, who are professionals and know the risks of failure, deserve a frank analysis. I would like to leave you with a message of hope. In my profession, the only real hope lies with the people. Since many of you deal with concerned citizens every day, take my message tonight back to them. Tell them they must supply the hope for environmentally responsible government policies. Tell them they can do it. And tell them they must.

2

CONVIVIAL STORMWATER MANAGEMENT ALTERNATIVES

J. TOBY TOURBIER, RICHARD WESTMACOTT AND CHARLES GOEDKEN

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Stormwater and flood management and their interrelationship to water quality are problems of national priority. The costs of urban flooding and drainage works on a nationwide scale have been estimated to exceed $5 billion per year (1) (2). There is an opportunity for substantially reducing the cost of stormwater management by examining and, where appropriate, modifying conventional practices. So-called "Blue-Green" stormwater technology, turns a liability into an asset by integrating control measures in open space systems. This concept recognizes the potential of streams, rivers and other natural drainage ways as multi-use urban open space/water systems; and it realizes the potential asset of stormwater by transferring some of the costs of stormwater management to other beneficiaries. We must seek solutions which are lasting, functional and beautiful, a technology for stormwater management which is convivial, with life and of life.

In the past we have tended to treat storm runoff under the "common enemy" rule of the drainage law. In the private sector, property owners often took whatever steps were necessary to keep water off their land, even if this was to the detriment of a neighbor. There have been variations of this rule, the "Civil Law" and "Reasonable Use" Doctrine. Yet what we see implemented is usually far from being comprehensive or ecologically sound. In the public sector, most local communities have tended to concentrate on improvements for minor storms. Predictably the elected official, with a limited time in office, often feels that it is neither wise to spend money on runoff pollution abatement, the benefits of which are rarely immediately apparent; nor on the control of floods with a low frequency of occurence, which are unlikely to occur during his term in office to demonstrate his wisdom and foresight. As a result emphasis has been placed on the design of conduits for minor storms. Public officials have also tended to favor highly visible improvements which benefit a clearly definable constituency. Unfortunately watershed boundaries are rarely contiguous with those of administrative constituencies and so improvements are rarely carried out comprehensively for whole watersheds. The problem is made worse by a lack of federal funding or legislation for comprehensive urban watershed management planning. Implementation depends on the initiative of local municipalities. Nevertheless there have been imaginative approaches, most notably in Maryland and Northern Virginia (3). Federal emphasis on water quality improvement makes the blue-green concept a more attractive approach to handling urban stormwater. Since 1972 there has been an expenditure of more than $18 billion in this country to make streams and lakes fishable and swimmable by 1983. As a result we may see a rise in waterside land values and a reorientation of cities which have, for so many years, been turning their backs on their waterfronts. Preserving the function of drainageways in their natural state has been found to be generally the most cost-effective approach (4). These stream valleys often have great natural beauty and the concern which many environmental groups show for these areas reflect the important ecological role which they may play. Water courses and their valleys can be designed for multi-use and managed greenways: they can incorporate appropriate stormwater management installations, recreation facilities and open space uses, pedestrian and cycle trails, and areas devoted to nature conservation. The benefits of such systems would best be demonstrated by prototype installations making use of land use controls, incentives, easements and covenants. Municipalities may wish to investigate the establishment of special purpose stormwater management districts with revenue raising powers, and may put to work knowledge about economic, legal, social and intergovernmental aspects of implementation acquired during the preparation of "208" plans.

We find that our concern to curb escalating public expenditure and our concern for the environment makes it timely to seek low cost, innovative ways to protect and improve the hydrologic function of natural drainage systems and to explore how these systems can be developed to improve our urban environments, through projects which are accepted and enthusiastically carried out at the local level (5). We must consider more than precipitation, drainage area characteristics, future land-use, risks incurred and the construction costs for stormwater conveyance systems. We must be aware of alternative stormwater management practices and their relative advantages and disadvantages. Practicality of implementation, cost-effectiveness, institutional and legal aspects and the political realities of implementation must all be carefully weighed. We must also be aware that we are often planning in highly unpredictable urbanizing situations where our plans should eventually result in a workable and comprehensive system. To implement such systems requires a program sensitive to the mandate of different units of government, their interrelationships, their funding and implementation potentials. Multi-use planning with emphasis on aesthetics and visual enhancement should not be the concern solely of public agencies but should involve private interest groups and organizations and developers. "Stormwater efficient" landscaping can save money and property values have been found to increase adjacent to greenways. There are four basic stormwater problems in urbanizing areas that can be solved through design solutions which can result in the enhancement of a site:

1. Increases in runoff and decreases in infiltration, which aggravate the problems both of flooding and low flows and cause a highly unstable hydrologic regimen, were lesser problems thirty years ago when roadside ditches provided temporary storage and increased infiltration. We can now achieve a similar effect by omitting curbs along suburban roads (Figure 1) and by installing gravel-filled infiltration ditches with optional perforated drainage pipe. Road surfaces can be constructed of porous asphalt which permits infiltration through its surface into a crushed stone base which also provides temporary storage capacity for stormwater. Regular road sweeping will prevent clogging of porous pavements which will be dry soon after a rain storm. Various forms of modular pavers can be set on sand or a crushed stone base to form pedestrian walkways and parking lots.

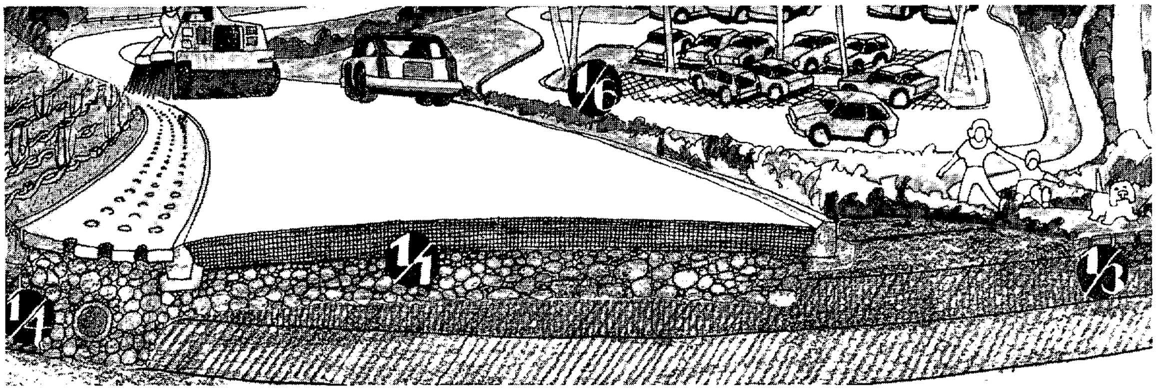


FIGURE 1 - INFILTRATION DEVICES IN URBAN DEVELOPMENT

2. Flooding and streambank erosion are problems which are directly related to runoff increase caused by urbanization resulting in higher flood peaks and a broadening of the stream channel. Streams which have serious bank erosion problems are often straightened, deepened, lined with concrete or culverted. Such channelization of course not only drastically reduces the biological function of a stream (notably its ability to recover from pollution) but also reduces the aesthetic quality of the stream and its floodplain. Less drastic, but often more effective "biotechnical" measures can take the form of jetties of rock-filled "gabion" baskets with live willow cuttings or wire mesh rolls of reed rhizomes and soil which are staked against eroding banks. Both measures result in permanent stabilization with natural riparian vegetation. Urban stream channels which have been neglected, modified or generally abused can be restored to a functionally attractive environment through a stream restoration program. Such a program must recognize the natural tendency for a stream to meander and seek only to direct this tendency. It should recognize the variable gradient of a natural stream channel with alternating pools and rapids and seek to enhance the aesthetic and ecological qualities of this diversity (6).

FIGURE 2 - BANK STABILIZATION USING ROCK FILLED GABIONS AND WILLOW CUTTINGS CAN IMPROVE WILDLIFE HABITAT

3. Erosion and sedimentation are caused by farming, forestry, mining - any land use which causes the removal of vegetation and disturbance of soil. Erosion and sedimentation resulting from construction activities during urbanization are most serious. They result in deterioration of stream health and siltation of rivers and reservoirs. Soil conservation practices can minimize soil loss from erosion and measures can be taken to reduce sediment in stormwater. Most traditional agricultural practices are based on sound soil conservation and frequently landscapes of lasting quality have resulted which are widely appreciated and highly valued. Stewardship of soil and water resources in urbanizing environments also results in higher quality urban environments.

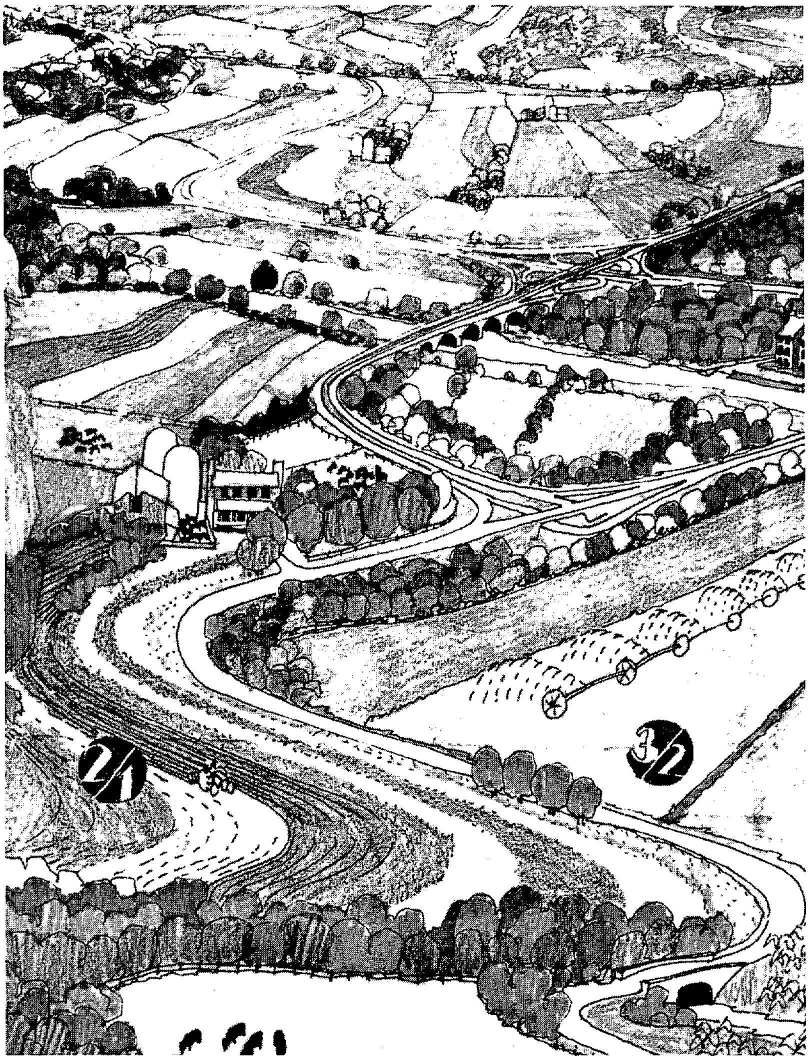


FIGURE 3 - EROSION AND SEDIMENTATION CONTROL THROUGH AGRICULTURAL MANAGEMENT PRACTICES RESULT IN BEAUTIFUL LANDSCAPE

4. Runoff pollution from urban areas was found to be the cause of much of the increased turbidity, oxygen loss and eutrophication of the Potomac in the Washington, DC area (7). This problem can be greatly reduced through "housekeeping" devices such as litter control, reduced use of pesticides and fertilizers near streams and bodies of water by maintaining "buffers" of vegetation along streams to filter runoff and to trap sediment before stormwater enters the stream. Natural wetlands and artifical marsh-pond systems can be used to improve the quality of runoff.

Management practices can be grouped into structural and non-structural measures. The latter include surface sanitation, controls on the use of chemicals, erosion and sediment control, and the use of natural drainage systems. Structural measures can be subdivided into "at-source" controls (including roof-top detention, porous pavement, Dutch drains, seepage areas, etc.) "up-stream" measures (mostly retention and detention after preliminary concentration) and "main-stem" structural measures. Until recently "at-source" and "up-stream" measures received little attention but recent studies have shown that they can be highly cost effective. A selection of these measures, outline specifications and costs, are described in "Water Resources Protection Measures in Land Development - A Handbook" (8) which is presently being updated by the University of Delaware Water Resources Center. Properly designed, such measures can enhance a site visually and will earn rapid acceptance by the public. Most water resources experts agree that not enough well-designed examples of such measures have been constructed to earn this acceptance and appreciation of the benefits. In most areas, environmentally "sensitive" lands tend to be found adjacent to watercourses. Simple overlay mapping will often demonstrate this dramatically as in the example of the Neshaminy Creek in Pennsylvania shown in Figures 5-7, where steep slopes, poorly drained soils and woodlands all are closely related to the drainage system (9). Figure 8 shows these factors combined as "areas of ecological concern." These areas form a system of "greenways" (10) which are ideally suited as special districts to demonstrate innovative and appropriate water resources conservation measures.

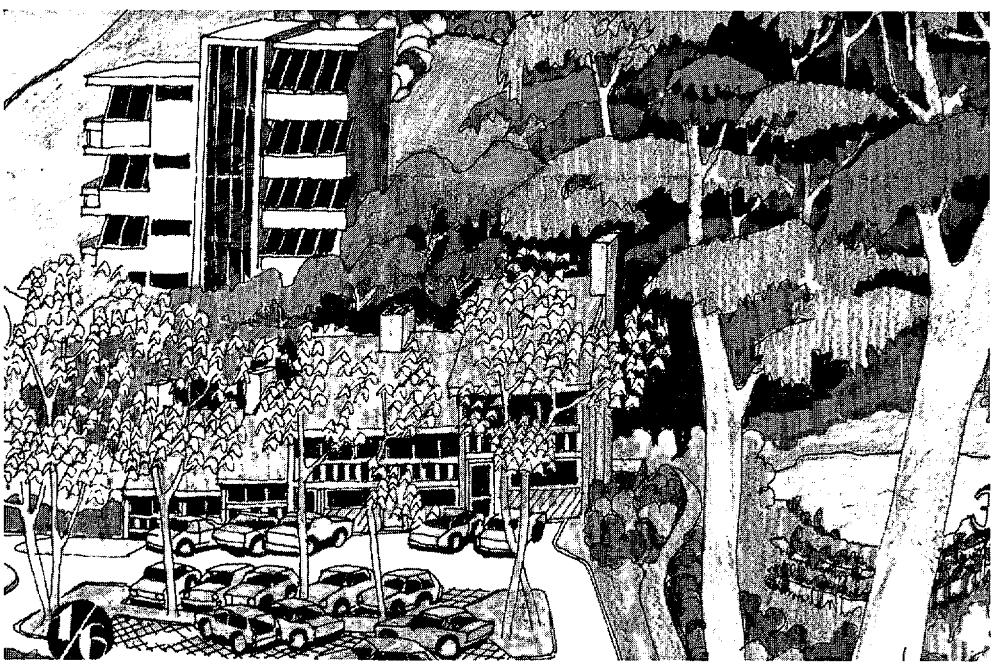


FIGURE 4 - GRASS WATERWAYS AND A MARSH/POND SYSTEM CAN BE DESIGNED TO IMPROVE THE QUALITY OF RUNOFF

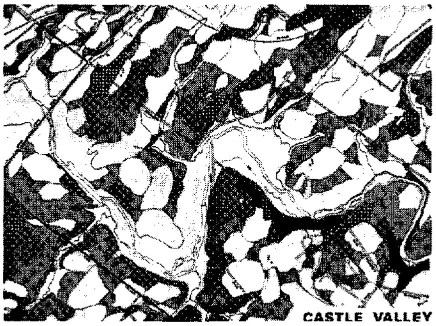


FIGURE 5 - STEEP SLOPES

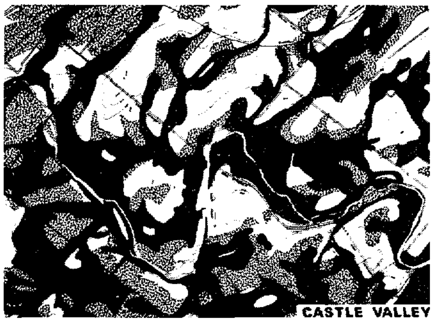


FIGURE 6 - POORLY DRAINED SOILS

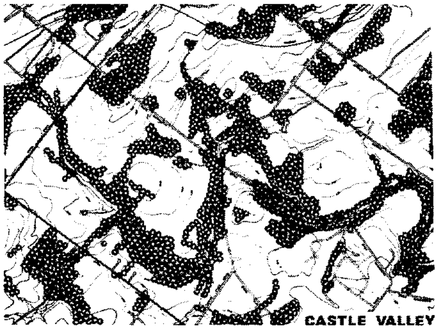


FIGURE 7 - WOODLANDS

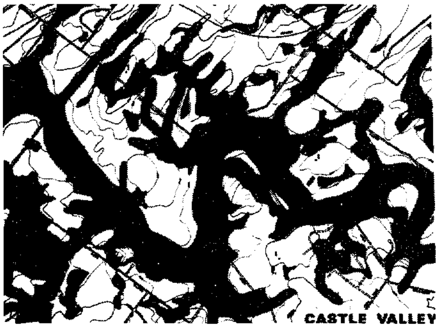


FIGURE 8 - CRITICAL AREA OF ECOLOGICAL CONCERN

Source: A Natural Features Approach to Stream Valley Planning (10)

Greenways are based on areas of coherent natural constraints in development which also offer the opportunity to "structure" urban development with a stream valley system which is functional, beautiful, and comprehensive. They provide for flood damage control, and protect water quality for the potential recreational use of "Scenic rivers" in an urban setting (Figure 9). Land-use controls for such areas should be selected according to development pressure, site characteristics and the vulnerability of the area.

For instance zoning as an open space control may not be challenged in areas with very little development pressures. But in an urbanizing area, zoning will come under heavy pressure and other techiiques, for instance the acquisition of easements and restrictive covenants, may be necessary to prevent undesirable land uses (11).

Greenways can be designated as special prupose management districts with taxing powers and a special review and approval procedure for development proposals. Enabling legislation for stormwater management

FIGURE 9 - GREENWAY STRUCTURES A DEVELOPING AREA [Source (11)]

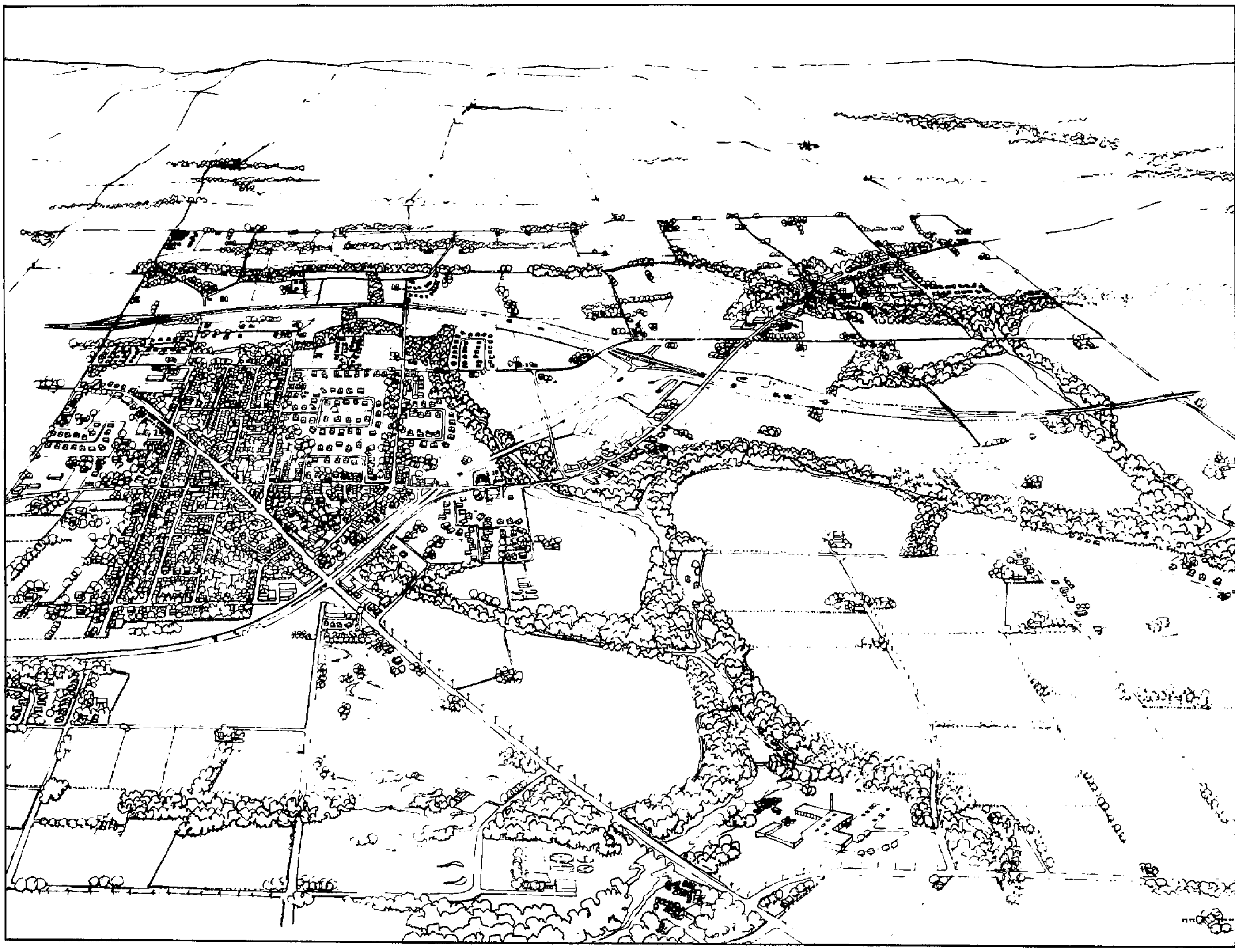
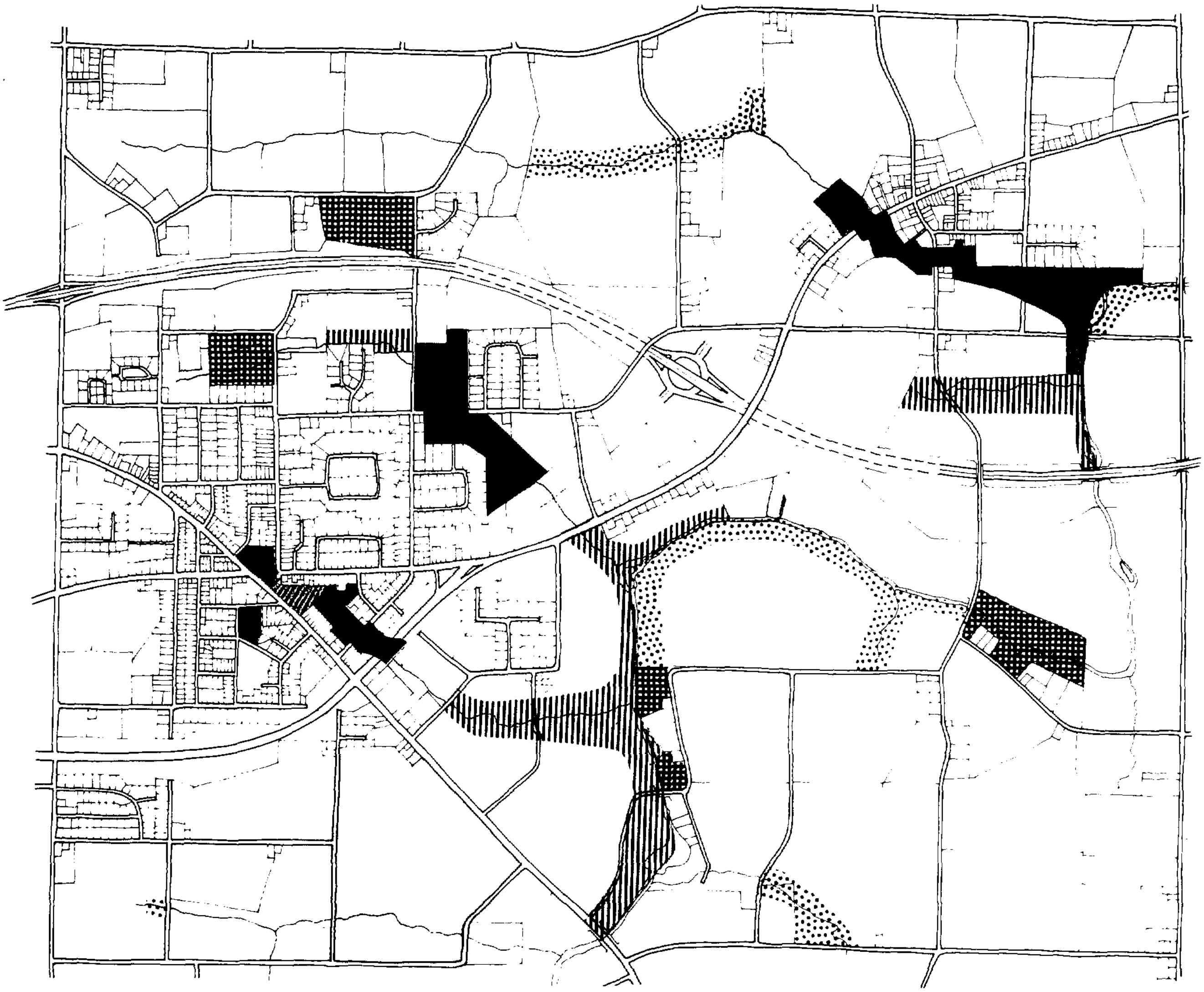


FIGURE 10 - LAND-USE CONTROLS TO PROTECT A GREENWAY [Source (11)]



RESOURCE PROTECTION AREAS IN OR ADJACENT TO URBAN AREAS

These areas, if not already developed, are suitable for public open space. All undeveloped parcels not in public ownership are included under the powers of Act 247.

Open space easement donated to the municipality.

RESOURCE PROTECTION AREAS IN OR ADJACENT TO DEVELOPMENT AREAS

These areas will be under pressure for development. Regulation will be insufficient to secure them. The parcels are included on the official map for purchase within 5 years, under the powers of Act 247.

Open space easement donated in return for a higher density allowance for cluster development on remainder of site.

Open space easements donated to municipality or County Conservancy.

Parcels purchased under the powers of Act 442. White areas resold for development.

RESOURCE PROTECTION AREAS IN RURAL AREAS

These areas are not under intense development pressure and regulation will usually secure them. They are zoned for open space/conservation. If failure of zoning appears imminent, steps to purchase an easement or full title should be taken.

Open space easement donated to municipality or County Conservancy.

Land purchased under powers of Act 442. White area resold.

is contained in state scenic river laws or other state laws such as the 1976 State of Maryland "Flood Control Water Management Act" or the Pennsylvania "Stormwater Management Act" of 1978. An alternative to such regulatory arrangements is voluntary compliance and public information through the initiation of prototype projects, where concepts and solutions can be demonstrated by example. Much blue-green technology is characterized by small scale, low cost, simple solutions which can often be constructed with volunteer labor and local materials. A greenway demonstration project can only succeed if the values of clean water, scenic stream valleys and stable environments are commonly held. A community should start by discovering for itself its common beliefs and values, before deciding policy and setting goals. In the past we have seen too many well-conceived plans and theoretical studies and not enough implementation. Implementation requires a concurrence of interest of resource user groups and public officials and a substantial agreement on a course of action (12). This requires public involvement in the planning process. The steps required are: (1) a convergence of interests, (2) legitimacy of sponsorship and (3) the establishment of an effectuation framework, leading to (4) the implementation of objectives (13). Blue-green technology will lead to substantial cost-saving in the construction of drainage works for both the developer and the tax-payer and lead to significant increases in property values. Figure 11 shows how such care for water resources can result in physical improvements that strike a balance between conservation and development.

FIGURE 11 -CONVIVIAL TECHNOLOGY TO PROTECT WATER (following page).

1/1 Porous Pavement, 1/2 Modular Pavers, 1/3 Perforated Brick, 1/4 Dutch Drain, 1/5 Downspout Disconnection, 1/6 Porous Parking Lot, 2/1 Contour Plowing, 2/2 Willow Pegging, 2/3 Hay Mulch, 2/4 Bio-Technical Streambank Stabilization, 3/1 Aerobic Digester, 3/2 Spray Irrigation of Wastes, 3/3 Land Application of Wastes in Greenbelts, 3/4 Marsh/Pond System, 3/5 Water Recycling in Spacecraft (14).

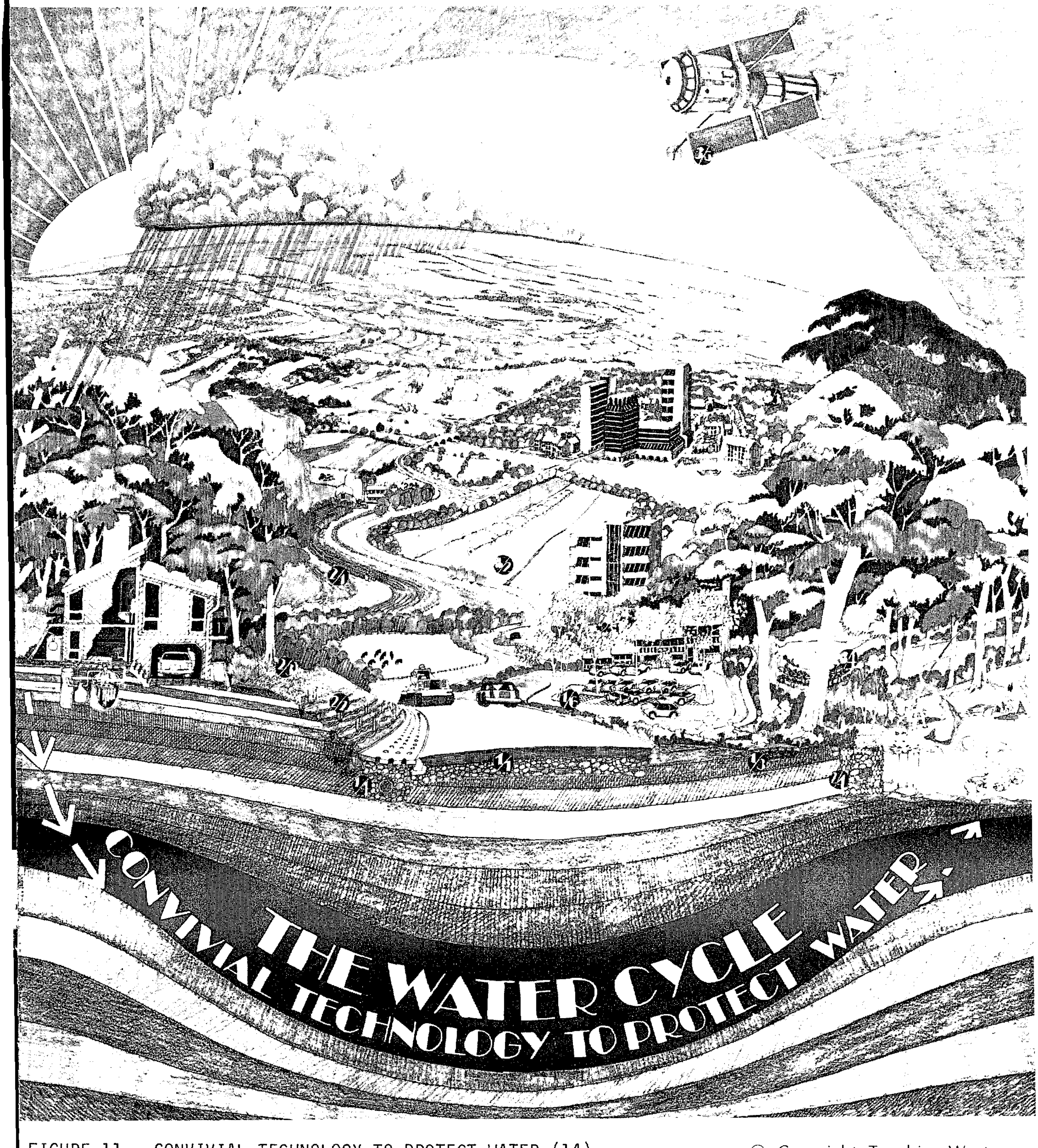


FIGURE 11 - CONVIVIAL TECHNOLOGY TO PROTECT WATER (14)

NOTES

(1) Neil S. Grigg, "Let's Settle the Stormwater Management Issue" estimates the national cost of stormwater management to be \$5-\$10 billion annually including capital and maintenance expenditures. See Chapter IV of this publication.

(2) D. Earl Jones, Jr., "Where is Urban Hydrology Practiced Today?" Journal of the Hydrologics Division. Proceedings of the American Society of Civil Engineers, (Feb. 1971). Jones estimates the direct economic costs of urban flooding as approximately \$1.6 billion per year. In addition American cities spend at least \$0.5 billion each year for necessary drainage construction. Storm drains built in conjunction with new streets and highways require \$1.4 billion per year. Federal flood control construction adds to this sum which easily amounts to a total of \$4 billion per year for direct losses and expenditures.

(3) Nazir Baig and Wesley H. Blood, "Stream Valley and Flood Plain Management in Montgomery County, Maryland," and John P. Hartigan, Bruce Douglas and others, "Areawide and Local Frameworks for Urban Nonpoint Management in Northern Virginia." See Chapter III of this publication.

(4) Hitman Associates, "Approaches to Stormwater Management," Columbia, Maryland, 1973.

(5) D. Earl Jones, Jr., "Urban Hydrology - A Redirection. Civil Engineering - ASCE, August 1967.

(6) E. A. Keller and E. K. Hoffman, "Urban Streams: Sensual Blight or Amenity," Journal of Soil and Water Conservation, September - October 1977: 237-340.

(7) C. Weis O'Mara, "The Problem of Urban Runoff." Environmental Comment, December 1978: 4-5.

(8) J. Tourbier and R. Westmacott, "Water Resources Protection Measures in Land Development - A Handbook." University of Delaware Water Resources Center, Newark, Delaware, 1974.

(9) J. Tourbier, "A Natural Features Approach to Stream Valley Planning - Neshaminy Creek, Bucks County, PA," Bucks County Planning Commission, Doylestown, Pennsylvania, September 1978.

(10) U.S. EPA Office of Land Use Coordination, "The Public Benefits of Cleaned Water: Engineering Greenway Opportunities." Washington, DC, August 1977.

(11) Joachim Tourbier and Richard Westmacott, "The Urban Fringe - Techniques for Guiding the Development of Bucks County." Bucks County Planning Commission, Doylestown, Pennsylvania, March 1970.

(12) The Institute for Participatory Planning, "Citizen Participation." University of Wyoming, 1979.

(13) Wade H. Andrews, "Sociological and Social Psychological Factors Related to Metropolitan Water Resources Development," Water and Metropolitan Man - Conference on Urban Water Resources Research. Proctor Academy, 1968.

(14) A 23" x 35" full color poster with two columns of text describing examples of water management keyed to the illustration is being marketed by the Bucks County Conservancy (a non-profit agency) 33 W. Court Street, Doylestown, PA 19901, Tel. (215) 345-7020.

3

APPROPRIATE STORMWATER MANAGEMENT

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Good afternoon. I've discovered two things: a new title for my lecture, and two minutes ago I found out that instead of speaking for an hour, I'm speaking for twenty minutes. So, I think you are very, very lucky. You have a speaker who is going to reduce his speech by two-thirds and speak on an entirely different subject from that announced. I suppose I should begin properly by congratulating the University of Delaware Water Resources Center for their initiative in creating this splendid conference. And, of course, I must congratulate my colleague, Toby Tourbier, who wears two hats: one at the University of Delaware and the other at the University of Pennsylvania. For him this is his second successful conference. His first incandescent success was the International Conference on the Biological Alternative to Water Treatment, which was published, and I'm sure this will be too.

Once upon a time, of course, the group of people who would attend a discussion on Stormwater Management would be very, very different from the people in this room. Had it been ten years ago, I suspect the overwhelming dominant profession would have been civil engineers, and all the people who are addressing the problem of stormwater management would have really operated within some simple principles, universally accepted. The first and most important thing was to get water into the pipe as fast as possible. The second would be, thou shalt solve thy problem at thy neighbor's and community's expense. Then the third would be that the meandering stream is to be abhorred and replaced as soon as possible by a straight stream. Moreover, a straight stream is to be abhorred and should be replaced as soon as possible by a channelized stream. And, best of all, streams should be culverted. These were, I think, the simple results which motivated stormwater management until very, very recently. There is the other rule that is applied to water which says, thou shalt defecate in thy neighbor's drinking water, and if thou does not do it, thy municipality shall do it for thee. Given these simple rules, it is perfectly easy to solve all the problems of wastewater, and of course, we did so.

It has taken a profound reversal of these historic views embodied in the National Environmental Policy Act, The Clean Streams Act, and of course, the massive expenditures of 208 money, to review these principles and reject them for heresies, or better, idiocies. What has happened, is that wastewater management must be considered as an aspect of ecological planning. I am delighted to find that in the preamble to the National Environmental Policy Act is language that is taken directly from Design with Nature. I am also astonished to see that in the 208 instructions, there is language from this same source.

I have never represented myself as knowing anything whatsoever about stormwater management. Nonetheless, because of the imprimatur which these two documents have given me, I propose to operate on the assumption that stormwater management is a subset of ecological planning, a subject with which I am familiar. So in the twenty minutes allotted to me, that is nineteen, I will now discuss ecological planning because I do believe that is the appropriate context within which all of the splendid technical papers you are going to hear should be considered.

I think that there is a splendid ecological theory which I can represent in a most simple paraphase. This simple paraphase is brief. It consists of a statement to the affect that all systems -- biological and social -- alternate between two states. One state can be called syntropic-fitness-health, and its antithesis is called entropic-misfitness-morbidity. Entropy is central to the second law of thermodynamics which states that all energy is destined to degradation. Syntropy if not the opposite, but there is a proposition that says under certain conditions certain energetic transactions, while increasing entropy, may in fact also result in matter and energy being at a higher level of order than that which was antecedent. For instance, there was a time, it is believed, when the world consisted entirely of hydrogen. There was a cosmic event called the explosion of a super nova, at the end of which there was a great deal more entropy in the system than before the event. However, there were other consequences - there was not only hydrogen, but helium, lithium, beryllium and boron and all of the elements of the periodic table. All the elements were created, so one could say that physical evolution is syntropic or creative. The second proposition is based on Darwin and Henderson and it simply says there is a condition called fitness. Darwin defined fitness by saying the surviving organism is fit for the environment. Henderson says that is quite true, but the fitness which is exhibited by environments, the fitness for organisms, is at least as important as the capability of the organism fitting to the environment. And, of course, there is then a misfit: the inability of any system -- physical, biological or social -- to find the most fit of all environments and adapt that environment and itself. The third proposition is linked to the former. It simply says that it is a condition of health. The World Health Organization defines a healthy man or woman as somebody who seeks and solves problems. There is no reference to pathology at all. There is a standby definition of health which says health is revealed by the ability to recover from insult or assault.

So here we have two single states which have three facets. One is called syntropic-fitness-health; the other is called entropic-misfitness-morbidity. There is a thermodynamic imperative in the quest to achieve syntropic-fitness-health because of the definition of fitness. A fit environment for any system -- physical, biological or social -- is defined by the degree to which the environment, as found, performs the largest part of the work required by the consumer. The environment as found -- physical, biological or social -- provides the largest amount of work required by the consumer. The consumer, whoever it is -- your cells, tissues, you as an organism, or you as an engineer, planner or landscape architect engaged in stormwater treatment -- in every case you must seek an environment that is suitable for the intended activity measured by degree that the largest part of work that has to be done is in fact being done by the system as you find it. The consumer has to do the least amount of work; that is to say, employ the least amount of energy -- import the least amount of energy -- in order to modify the environment in order for it to perform for the consumer. This is a thermodynamic imperative which Mr. Schlesinger never understood and which is not widely understood in the Department of Energy. But nonetheless, every little plant and every single microorganism and every single animal in the whole history of evolution has had to respond to this thermodynamic imperative of fitness. So that's the theory. There is something called syntropic-fitness-health and there is another state called entropic-misfitness-morbidity.

The mechanism used to solve fitting is adaptation. There are three types of adaptation, first physiological through mutation and natural selection, second behavior and third, culture. We can't do very much about the first one. The only thing you can do about it is to choose your spouse with some sort of genetic concern, which is unlikely. The second instrumentality for adaptation is called innate behavior. Unless you believe in Valium and mind-changing pills, we have to assume that this is not amenable, really, to conscious manipulation either. Which leaves us with a third instrument of adaptation - cultural adaptation, which, of course, is most plastic of all.

Now, what are the instrumentalities of cultural adaptation? Of course they are language, religion, law, government and so on. But I will say to you: if you address Darwin and Henderson's proposition about fitness and survival (the surviving organism is fit for the environment), then of all of the instrumentalities available for successful adaptation, I will say the most direct one to satisfy this quest is called planning. If Darwin is right, a surviving organism is fit for the environment; and if Henderson is right, the actual world consists of an infinite choice of environments. There is a necessity for any system, biological or social, to find the fittest environment and adapt that environment to itself. If fitness is defined by the degree to which the environment as found performs the largest part of the work required by the consumer, we have an extraordinary model. We see that the instrumentality by which we can accomplish this success is called planning, which we then have to define.

I would define planning as the formulation of alternative futures, and then the recognition that these alternative futures require actions and courses of action. Then, the necessity of transmuting every single one of these contemplated actions or courses of action, (and you can immediately address stormwater management within this) into costs and benefits. At which point one realizes that this poses a very serious problem, because what is valued by any person is likely to be different from that of any other person. We will have variable values with respect to different people, different ages. As a matter of fact, you may even find that the same person will have different values at different times. That is, the values I espoused when I was 25 are very different from the values I now espouse at the age of 58. For instance, at 25 my idea of a great time was a very, very small room, a lot of alcohol, a whole lot of single women (I was then single), and a great deal of noisy jazz. This was my idea of an absolutely marvelous time. Now at 58 my idea is a small room with a fire with one woman (already selected), a certain amount of wine rather than hard liquor and rather softer jazz (Milt Jackson instead of Armstrong). There has been a profound change in values.

So, the important thing to recognize for all planners is, of course, that all values cannot be attributed; values can only be elicited. You have got to ask people what their values are. When they tell you so, such values, once elicited, are data to be employed in planning. The resolution of this Darwinian proposition is already revealed; that is, the requirement to find the most fit of all environments and adapt that environment and yourself. What constitutes fitness in not only a thermodynamic imperative but also includes formed and social values. So one has then got to find out who the consumer is and what the needs and desires of the consumer are. An individual, a family, an institution, a community, a regional sewage treatment district, whatever it is, you have got to elicit from them what their needs and desires are. From these you can formulate their alternative futures. These must then be reconstituted into actions or courses of action, next into cost and benefits. And the most fit solution will be the least-work-maximum-success solution where the needs and desires can be best satisfied by the environment as found; where the modifications to that environment are less than for any other consumer.

I think it is a very powerful formulation -- this ecological model. It's a pity it's not more widely understood and more widely used because it seems to be absolutely the context within which all of us must operate. Because what you do is efficacious to the degree to which you understand you're engaged in adaptation and a quest for fitness, this really requires you to find natural systems which have some capability of satisfying the problems which we seek to solve. And moreover, you have to operate from the presumption that the natural system is in fact a criterion of excellence. If we assume now that we are engaged in an ecological planning problem, we have to recognize that the understanding of this biophysical and cultural system is a precondition for a successful operation. Because I went to Harvard and never encountered any natural science whatsoever, I've had to spend 25 years at the University of Pennsylvania learning natural science very laboriously to compensate for the inadequate, but expensive, education that Harvard gave me. I go there each year for a very, very small honorarum in order to say that, while I have three degrees from Harvard, and they have conferred instant respectability on me as others, but they are, of course, no substitute for an education.

In the remaining five minutes I will describe the ecological context within which all stormwater management must operate. That is, you have to understand the operation of this biophysical and cultural system -- not only descriptively, but as quantitively as possible. Moreover, you must have as much predictive capability as science can offer.

So let me tell you how students at the University of Pennsylvania and colleagues of mine operate to create, for any problem, a biophysical/cultural model with as much description, as much quantitative capability, as much predictive capability as possible in order that we may solve problems. We start with the oldest evidence first, which is bedrock geology. We hire a bedrock geologist to cap the geological phenomenon, because only by an understanding of geological history can phenomena be explained. In the process of reviewing geological history one understands, not only the phenomena, but the dynamism of the processes. One hires a meteorologist to do exactly the same thing. Then one hires a ground water hydrologist, who then, of course, has to use the data from meteorology and bedrock geology to explain ground water hydrology. You hire a physical geographer or a geomorphologist, to reinterpret bedrock and surficial geology in terms of geomorphology or physiography. At which point, you hire a hydrologist to invoke meteorology, gravity, bedrock geology, and surficial geology to explain surface water hydrology. At which point, you hire a soil scientist to tell you why soils are what they are, where they are -- which you could do very well by invoking all the information from meteorology, bedrock geology, surficial geology, ground water hydrology, and surface water hydrology. At which point, you hire a plant ecologist to explain why plants are what they are, doing what they are doing, going where they're going -- which he can do, of course, because he defines environments with reference to meteorology, bedrock geology, surficial geology, ground water hydrology, physiography, surface water hydrology and soils. At which point, you hire a wildlife ecologist who employs all the preceding data which he can redefine in terms of habitats. At which point, you have a layer cake biophysical model in which you've used chronology -- the oldest evidence first, the most recent evidence last -- to explain reality and also to get some understanding about the dynamism of the system. Then you want to understand this as a biophysical/cultural model because we're much more interested in man and his follies than we are with plants and animals.

So then you have a different group of people dominated by ethnographers and anthropologists. They go through an exercise in which they take the primeval environment as found and they operate within an anthropological model which can be summarized as follows: The anthropological model says a natural system is a natural system (that's the kind of assertion that you can safely make). It also says a natural system is simultaneously a social value system because it contains resources. Then you note resources are really in the eyes of the beholder. They are a function of the perception of the onlooker or the inhabitant. But if the inhabitant perceives something to be a resource, and there is a technology of capital and labor and so on available to use it, then the resources will locate the means of production. Then the next thing you observe is, in America historically, the means of production has in fact selected particular practitioners who are skillful at it -- whether it was lumbering or shell fishing or farming or coal mining. The selected people are skilled in the operation which they acquired from environments where similar resources existed, mainly in Europe. It is important to recognize that in early American history these people had not only an occupational identity, but they had an ethnic one and frequently a religious one as well. Where you have people who have an ethnic identity, an occupational identity, a religious identity, and a spatial identity associated with a single means of production, it is likely that they will have characteristic settlement patterns, they will have characteristic institutions. By this method one comes to an extraordinary revelation, which was certainly never revealed to me through all of the social science that I studied at Harvard. Nobody there believed that man was systematic and certainly nobody believed that nature was systematic, or cared. Absolutely nobody gave any thought to the conception that man and nature were systematic. I assure you, that if you perceive through this biophysical-cultural-evolutionary analysis, you will find indeed that people are where they are, doing what they are doing for very good and sufficient reasons. There is a causality about people and their occupations and their values perfectly as comprehensible as the presence of plants or animals or rocks or soil.

Within this larger view which I hope you will use as the context for your further deliberations, there are some sort of particular ones. That is, if you do this sort of ecological survey, if you in fact understand the system as an interacting biophysical system, if you understand that there are particular people there doing what they are doing for good and sufficient reasons, then you will see that there is likely to be generic problems. This should not surprise anyone devoted to the ecological view. I think one of the most extraordinary accidents and unhappinesses of the evolution of civil engineering in the United States was that it developed in the crystalline Piedmont. This is not unexpected because it occurred in New York, in Boston and in Philadelphia; the largest part of which urbanization did occur in the crystalline Piedmont where the rule was very, very simple. It was assumed that the best and the most important thing to do was to get the water off the ground as fast as possible; drain it off and get it into pipes or into surface water systems. And of course, this holds true in the crystalline Piedmont. By and large, it's not a bad proposition; it may be simple, but it's not idiotic. But of course, if you applied it to the larger part of the United States where the great sedimentary basins like the midwest or the great coastal plain which goes from Cape Cod all the way down to Florida and Texas, it is of course a pure idiocy.

I think there will be, in subsequent presentations, some discussion of exercises in which I was, myself, involved with my colleagues, Narendra Juneja and Jim Veltman: the New Town of Woodlands, the ecological study and plan and ordinances for Medford, a study for Lake Austin, and of course, the study for Sanibel, Florida -- all of which involved ecological studies, the development of ecological ordinances, and in the ultimate case of Sanibel, the production of an ecologically based plan.

From these studies, and other, it became clear that there are generic solutions which are characteristic of physiographic regions. For the coastal plain it was clear that there were two very important purposes: one did not wish to increase discharge to surface water and one did not wish to diminish recharge to aquifers. It was possible then to allocate to both of these a maximum discharge value for every land use type, every slope category, for every soil type, for every vegetative cover and every land use. It was appropriate and possible, then, to write ordinances which allocated maximum discharge for every land use in every single area in Medford. And it was also possible to allocate a minimum recharge, which was a burden and a requirement for every land use and every land owner. This was transmuted into ordinances. I suspect that this really is an intelligent way of the future. That is, if we have ecological planning and if these understandings prevail, then ultimately they will be transmuted into ordinances.

Beyond that, there is one other conception which developed from these studies, which presumably Narendra Juneja will discuss when he talks about Woodlands -- that is the conception of clearance-coverage ratios. I think this really was an invention and a really gratifying one. We were confronted with the necessity of developing 20,000 acres of land, oak-pine woodlands 30 miles from Houston, land which traditionally had been very, very difficult to develop. In conventional engineering, the solution was to drawdown the water table -- which is a perfectly good idea if you're a short-term subdivider and you want to get in, build, get your money, and get out and don't mind killing the forest. But it isn't a very good strategy if you're going to stay around long enough to build a new town and the forest is the most valuable market commodity. So in this circumstance we had to devise a method by which it would be possible to maintain the forest which George Mitchell was selling and yet solve the very, very difficult problems of drainage, including 13 inches of rainfall in 24 hours. This was done by natural drainage. It is very gratifying to find all these techniques of natural drainage of swales, detention basins and sediment basins, and of artificial recharge worked wonderfully and successfully.

Best of all, the conception that I think is original and deserves some sort of discussion here, is the conception of clearance-coverage ratios. In this particular case, there is a fragipan on the surface in many cases. With the single exception of very permeable bog soils, all the rest of the soils had a fragipan from the surface to a depth of 24 inches. So, the amount of water storage was very small; the permeability was very small, except for these extraordinary bog soils. It was possible in this particular case, to develop a coverage ratio to say that where the fragipan is on the surface you can put as much asphalt, you can put as many roofs as you like, because there is no way in which you can increase the coefficient of runoff. It's 100 percent right now and any human cannot make it any more than 100 percent, so you can have total clearance and coverage. You can cover it totally with no social detriment whatsoever. At the other end of the scale are the bog soils, which are sumps and to which all surface water was deflected. These, in fact, were recharging the aquifer. In these areas, we said absolutely no clearance and zero coverage -- absolutely none, the soils supported the richest forest -- water and willow oaks. So within the gradient of a distance of the fragipan from the surface and the water storage capability, it was possible then to allocate a gradient of densities. Now that's a long span from creativity-fitness-health to fragipan on or near the surface to within 24 inches. But it seems to me, the ecological point of view, I think, has, because of its theoretical basis, the capability of dealing with problems in terms of first principles and producing adaptive mechanisms and strategies which are appropriate and which of course are convivial.

So with my last minute, I can now tell a little story about the conversion of someone else to the ecological planning method. The same George Mitchell, president of Mitchell Energy, One Shell Plaza, Houston, the founder and creator of Woodlands, New Town, Texas, was a man who was very, very suspicious of ecological planning. So there are two things that happened to change his mind: 1) the requirement of getting $50 million for Title 7 was very, very important. At that time HUD was environmentally sensitive and indeed, there was a man called Tony De Vito (whom I think I helped to make somewhat environmentally sensitive) who was at HUD and was going to review this application. So the ecological study was unbelievably elegant. It really was very, very complete indeed, and so George Mitchell got his $50 million. This aroused his ecological interest. And then came the next point, 2) where we were unable to drawdown the water table, destroy the forest, utilize conventional engineering. Narendra Juneja, Leslie Sauer, a number of other people and myself invented natural drainage. And I remember very well the day in One Shell Plaza when we confronted George Mitchell with the fact he couldn't have conventional engineering, but he had to have something which God invented a long time ago and which we had rediscovered, called natural drainage. He was very suspicious about this and he said, "What are the implications of this?" And I said, "Mr. Mitchell, the implications are very simple, you can't and should not, need not, have a storm drainage system." He said, "Mr. McHarg, really what are the ultimate implications of this?" And I said, "George, at the outset it will save you $18 million." His conversion was immediate and complete.

4

LEGAL TOOLS FOR THE IMPLEMENTATION OF GREENWAY AND BLUE-GREEN TECHNOLOGY

ANN LOUISE STRONG

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Ian has provided you with the inspiration and I am supposed to provide you with the implementation. I have a problem that Ian didn't have; there isn't really much stormwater management case law to talk about. Therefore, I will talk about legal principles and analogize from other laws and cases to stormwater management problems. I will also offer you my own opinions, which are shaped by a fair amount of experience in environmental law. First I'm going to describe how I look at the problem of stormwater management and give you a few examples of legal issues with which I'm personally familiar. Then I'm going to present some proposals for dealing with the types of issues which arise, discuss the problems that these proposals present, and finally offer a few conclusions.

Stormwater management law is not a well defined area; such laws as there are vary considerably throughout the nation. Perhaps no aspect of stormwater management leaves as many unanswered questions as the legal aspect. There are a fair number of state enabling acts which pertain to stormwater management and there are many local ordinances, but there is little judicial precedent concerning either the state acts or the local ordinances. Therefore, I am going to turn to precedents in analogous areas.

There is a very famous Wisconsin Supreme Court case called Just vs. Marinette County. The state of Wisconsin has a mandatory shore line regulatory act which says that every county in Wisconsin must develop regulations for land within 300 feet of all streams and 1,000 feet of all lakes, and that if any county fails to adopt such regulations the state then must adopt regulations for those areas. The Marinette County case involved some property owners whose land was within 300 feet of a stream. These land owners wished to build some cottages. The County ordinance prevented them from doing so. The Supreme Court, in upholding the ordinance, which did not offer compensation to the land owners for the prohibition on development, said that man has a right to use the land only as it is in its natural state. In other words, we have no economic right to build an office tower, to build an apartment building, or to build anything. The Court said that we have a public trust obligation to the generations which will come after us to protect the natural resources of the land. Now, while that is an opinion with which I profoundly agree, I cannot tell you that many other states have followed it. The case has been cited a number of times, and many states have upheld regulation of wetlands or floodplains. The other state decisions, however, are not based on a public trust obligation but on reasonableness of the regulations under the police power.

Characteristic Stormwater Management Issues:

How do these decisions relate to stormwater management? Several kinds of land are affected by stormwater: rural land, land that is under development, and land that has been developed already. The components of the stormwater with which we're concerned are the water itself, the soil which it carries away, and the pollutants. Management problems include development of plans, implementation of these plans, maintenance of whatever stormwater systems we develop, and payment for the systems. The major legal areas to consider are, first, whether or not the stormwater management system adopted yields a public benefit sufficient to warrant imposing restrictions on private land owners; second, whether this system has in fact been authorized by any legislation; third, whether there is authorization to tax to pay for the system; and fourth, whether there is private landowner liability if the system malfunctions. My three illustrations -- one each for rural land, land under development, and developed land -- of stormwater management law issues are rather homely examples, chosen because they are familiar to me. First, I will describe a fact situation and then the legal problems that the fact situation presents.

My husband and I bought some land in the Brandywine Valley a year ago, little thinking that we would face a rural stormwater management problem. Our land includes a ten-acre moderately steep hill on which hay has been grown for many years. At some time in the past someone had installed a french drain to direct the run-off from the hill away from the house. Someone also had built a berm along the road and had installed a concrete drainage pipe to carry away the stormwater so that it would not go across the road into the neighbor's cellar. The property also has a farm pond with a large stone retaining wall which we have been told is just about to collapse. Last winter's deep snow and this spring's heavy rainfall led to substantial, continuing runoff. Our tenants complained that the water shoots into their basement, because the french drain no longer works. They alleged that we are liable for the ruin of various pieces of furniture and carpets that they stored in the basement. The runoff poured across the road and flooded the neighbor's basement, damaging their furnace, because the drainage pipe had been crushed and filled over time. The neighbors alleged that we are responsible for their water damage, bacause someone had previously installed a structural improvement to carry the water away from their house. Since this improvement no longer functions they alleged that we have an obligation to replace it. There are a number of legal questions which arise in addition to those of liability for damages. Could an ordinance specify that we should manage the land so that the hill has no more than the "natural" amount of runoff from my hill? How would we determine what is "natural"? Today the hill happens to have hay on it. At some point in the past I presume that it was wooded. At some time it may have been cropped. As you all know, the runoff characteristics vary depending on what the vegetative cover is. What could we be required to do to limit runoff to whatever might be defined as "natural"? For instance, as part of a 208 plan, could we be required to contour plow or to plant specific crops? Could we be required to plant trees, because the hill is quite steep and the soil is not good? Or, can the ordinance only set performance standards that leave to us the manner of controlling the total volume of runoff? What is reasonable? What size storm must we plan for? Can the ordinance require that the runoff from a 100 year storm be accomodated and not reach either house? Of what relevance is the cost to us of achieving whatever the runoff goals may be? Then there are the legal issues connected with the farm pond. May we have to dedicate a stream easement for flood protection if the pond collapses and no longer provides this protection? What if the neighbor's child drowns in the pond? Is the pond an attractive nuisance imposing liability?

Now let's look at some of the legal issues which face someone developing land. There is a property about a mile from my house, familiarly known as the duck pond. It is a beautiful estate, with lovely sloping lawns, a stream, a series of ponds, and many waterfowl, which is now being developed. The developer has agreed to dedicate the stream and the ponds to the municipality. In the meantime, he has stripped topsoil from the site and piled it up, while he grades and digs for roads, sewers, and houses. He has put bales of hay next to the stream, spread hay over the open ground, and planted quick growing grass in compliance with the township ordinances. He has just been told that the municipality may adopt a two year moratorium on all development in his area because of general runoff problems. He has his mortgage commitments and all his financing. He has put in the sewers and the storm drains. Can the municipality impose a two year moratorium on further construction? What is a fair performance standard for runoff from a site like this? The estate had grass lawns and it has been a long time since the area was in any farm or forest use. Should the ordinance measure changes in runoff from the lawn as a base, or should it establish a base given some general characteristics for the locality? Can the developer be required to install runoff controls based on needs of either the municipality or the watershed? What if he says that he can meet the runoff standards more cheaply by means that don't comply with the specifications of the ordinance? From a municipal or watershed perspective is it sensible to require each developer to carry out the stormwater management plan on each building site? Is there a limit to the costs which the municipality may impose? Once the houses are sold who is going to maintain the runoff control system?

The third set of issues relate to already developed land. Within a mile of my house a municipal storm drain empties above a developed lot. The local newspaper recently reported that the lot owners had just removed six truckloads of debris from their land and that they now had a six foot deep ravine behind their house, both as a result of the outpouring of the municipality's stormwater. The paper quoted the wife, protesting to the municipality's supervisors: "We have built dams but it's getting to be too much for me and my husband to do the shoveling out." The chairman of the board of supervisors wasn't very sympathetic. He said, "Well madam, there are lots of other people here having similar problems and we don't have much money to spread around. We'll come out and look at your property." What is the municipality's obligation when a stormwater management system has been built and doesn't function adequately? How much burden can be placed on property owners?

Legal Proposals:

Having characterized problems typical of rural, developing, and developed areas, what do I propose? My goal for local governments is that they should design to contain the 100 year flood within small basins -- say approximately 10 square miles -- and that they should design to contain a two year flood within subdivisions, placing the latter obligation on subdividers. Some definition of the difference between "natural" runoff and expected runoff after the development is needed. My inclination would be to use average rural runoff for a small watershed. In the Brandywine, for instance, there is a mosaic of woods, cornfields, and pastures on a moderately hilly terrain. I would calculate runoff for the various vegetative and topographic conditions, establish an average, and call that natural. This would be the base for comparison to what one would anticipate during and after development.

I think we should rely heavily on our existing governmental structures for regulating runoff. Farmers especially are going to be resistant to requirements to carry out specific land use plans. We will do better by using conservation groups, such as the Brandywine Valley Association, to teach and encourage people to use their land wisely. This alone will not be enough. Many local governments in this area have zoned the 100 year flood plain for non-development. This restricts about three percent of a watershed. In addition, some buffer adjacent to streams is needed. A 300 foot buffer seems to be as reasonable a distance as any. In this watershed that buffer constitutes 23 percent of the land. I don't believe it is legally feasible or reasonable to attempt to zone that much land for use compatible with runoff control. Therefore, I think there has to be a public expenditure to acquire easements. In the buffer areas, one should plant vegetation which will maximize infiltration and capture sediment, thus also preventing or minimizing channel erosion. We need to regulate use of pesticides and use of fertilizers so that we don't have excess runoff of both of them.

For developing areas, I would prefer to see the state mandate either county or municipal stormwater management plans, and require that these plans be for watersheds rather than for government boundary units. If there isn't a state mandate, enactment by local governments will be very spotty. Therefore, we have a better chance of getting broad scale action if we work for good state enabling legislation. This also should include a back up, as in the Wisconsin shoreland law, so that if a local government refuses to act, the state not only can but is required to act. As for rural areas, I think the plans should require that the 100 year flood be accomodated within the basin and the two year flood within a subdivision. The runoff and erosion should not be allowed to exceed the average I defined as natural for the area. Also for rural areas, I favor relying on zoning for the flood plain. For structural measures, ponds, and retention basins I favor use of performance standards so that the developer has the option of determining what means can best be used on a particular site. I believe that the developer should pay for the system to control site runoff. Once it is built, the local government should be given an easement for site access and should maintain the system. It is very impractical, once a subdivision has been built and the houses sold, to expect the home owners to maintain the system. The use of a drainage district utility easement is a practical method in which the district sells revenue bonds, assesses the owners who are benefited by the system and imposes a monthly service charge for maintenance. I think there is some problem in having an existing government do the stormwater management planning and then entrusting a utility district with responsibility for finance and maintenance of the systems built. It would probably be preferable, both for planning and implementation, to have the same body do both but local governments may not have the power to sell revenue bonds. If not, this may lead to use of something like a utility district.

Another financial problem may arise with installation of a large scale storm water management system. If an area is undergoing development, but a good bit of land is not going to be developed for some time, the cost of the system could be a very heavy burden on those people who don't want to develop. It is not clear under what circumstances they may or may not be forced to pay for part of the system.

I have stressed working to get good state enabling legislation, followed by local planning and implementation. However, adoption of a good law is futile unless it is enforced. This is a very serious problem in many places at both the state and local levels. One way to get adequate municipal budgets for enforcement is to emphasize how much failure to manage stormwater costs. Ian's illustrations show that you can sell something by demonstrating to the legislature or to property owners that planning with nature is cheaper than waiting for floods and then building channels, culverts, and dams. We have made quite a bit of progress recently in some states with enabling legislation and in many municipalities with local programs. But, we have a very long way to go. We need to follow up on some of the innovative programs, find out how they have been accepted, and show that they have in fact been better and cheaper than other alternatives. The courts will be supportive if shown that the programs are fair and reasonable.

5

THE BLUE-GREEN CONCEPT - SOME PERSONAL COMMENTS

RICHARD WESTMACOTT

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The Blue-Green Concept is a deceptively simple one. Why there are so few examples of this idea which have been consciously carried out is somewhat of a mystery. For those which do exist, whether they have simply evolved, or whether they result from conscious design have been extraordinarily successful.

Earl Jones first coined the term 'Blue-Green Development' in the 1960's. He described the principles of the concept in an article in the ASCE Journal in August 1967 entitled "Urban Hydrology - A Redirection." Because of illness Earl Jones was unable to attend the conference today, nor was he able to prepare a paper. I am not going to try to cover in detail the opportunities and implications of the Blue-Green Concept. Rather I shall run quickly over my interpretation of its principles, throwing in a few comments of my own, and then ask for your observations and experiences.

When the term 'Blue-Green' was first used at FHA, it referred to the planned integration of water areas in open space systems, multi-functional impoundments for both the detention of runoff and for aesthetic benefits. From its conception, storage and detention of urban stormwater were important features of Blue-Green development. The concept recognizes the multifunctional role of natural drainage systems, and it is probably in large part due to failure to recognize the many roles which a stream or river in its natural setting can play, and the extraordinary influence which it can have on the quality of the urban environment around it, that so few cases of this concept have been implemented. It is also in part due to the failure to recognize that our cities "have two separate and distinct storm water drainage

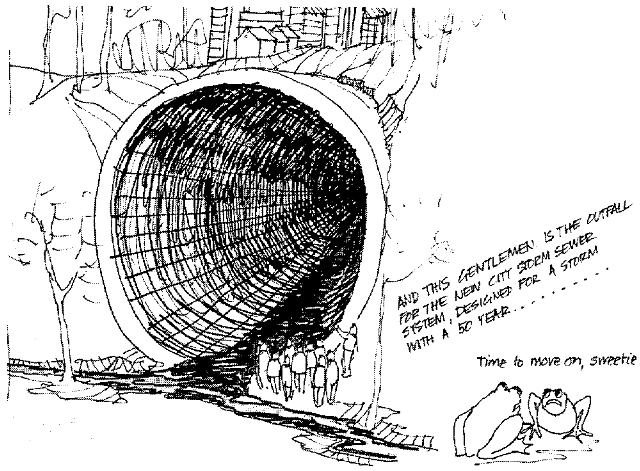
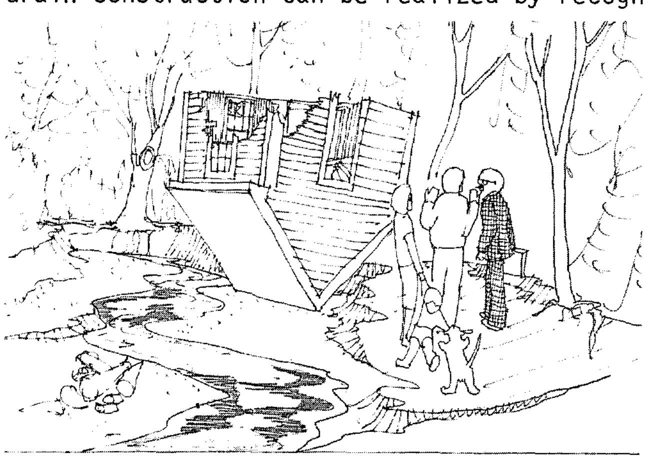


Figure 1

systems, a 'minor' system and a 'major' system." The lack of attention and conscious design that the natural or 'major system' has received in the last 3/4 century has been largely due to our preoccupation with the design of the minor system, that complex of carefully engineered closed and open conduits.

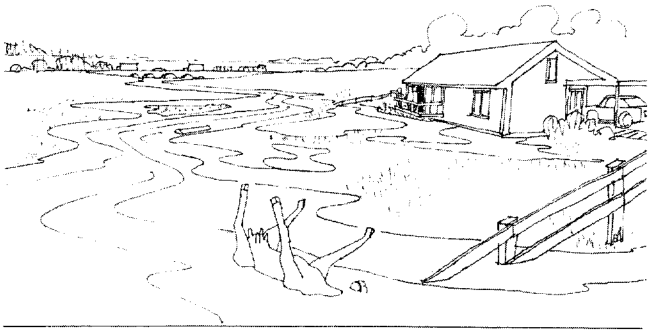
The design standards for these minor systems have steadily increased with the arrogant misconception that it is economically feasible to construct a system which will never overflow. Earl Jones pointed out in 1967 that 30 years ago cities were using design frequencies of 2-5 years. "A few were using a 5-10 year figure in intensively developed downtown commercial areas . . . . Today (1967) most cities have increased their basic design frequency to from 5 to 10 years, and some use a basic design frequency of 25 years or more . . . ." Earl Jones continued "The adoption of the higher minimum design standard for the minor system usually is indicative of a failure to recognize the existence of the major system, or of the economics or risks involved."

Lack of attention to the major drainage system and increases in urban runoff also, of course, resulted in serious degradation of innumerable streams as they eroded their banks, scoured their beds and washed away development on floodplains ever increasing in extent. Urban streams became unstable, polluted and unpredictable and people turned away from them. Earl Jones suggests that "Man's relationship to the major system is a measure of his wisdom." Furthermore he points out in the Journal of the Hydraulics Division of ASCE in February 1971 that savings of at least 15% in routine primary storm drain construction can be realized by recognizing the function of the



YES . . . but that was the 100 year flood plain before we developed the tract . . . Figure 2

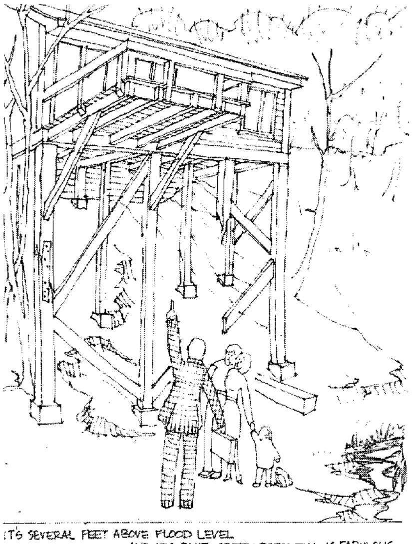
major drainage system. Awareness that in spite of billions spent on flood control, that flooding is a natural and inevitable phenomenon, together with recognition of the vital role which the major drainage systems of our cities play in this respect, has been slow to dawn. Slow too has been the application to urban areas of SCS principles of retaining runoff, but today retention of runoff and other upstream measures to reduce peak flows and erosion in developing areas are everyday development practice in many areas. Blue-Green embodies all these concepts but also places emphasis on the value of the aesthetic qualities of the waters edge and its potential for improving the quality of urban neighborhoods.



IT MAY SEEM OMINOUS BUT ITS REALLY QUITE GENTLE.....

Figure 3

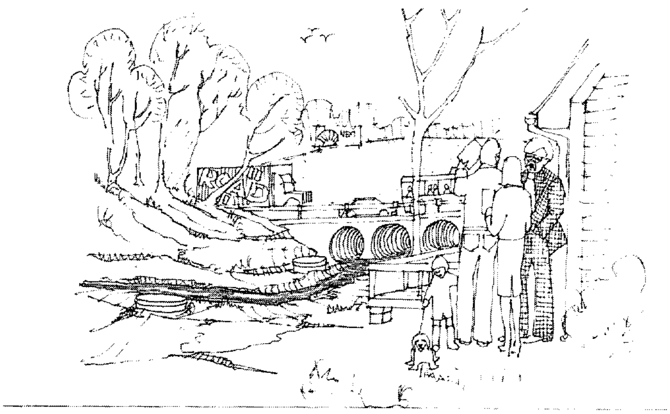
The attraction of water, quick or slow, noisy or silent is extraordinary but it is in the setting of streams and rivers that much of their attraction lies, whether it be steep wooded valleys, riparian meadows, or expanses of estuarine wetland. These are as important to the aesthetic qualities of the river as its floodplain is to its hydrologic function. Evidence of the premium that homeowners are prepared to pay for property with stream or lake frontage can be found in several studies. But riparian open space has one characteristic which is vitally important to the Blue-Green Concept. This is its continuity. Continuity is crucial if open space is to provide a framework for non-vehicular circulation, and we should realize this opportunity which is intrinsic to river systems. However, private tenure of riparian land may interupt this continuity. Earl Jones emphasizes strongly that, in cases which he had studied where open-space is publicly owned, the benefits in terms of increased property



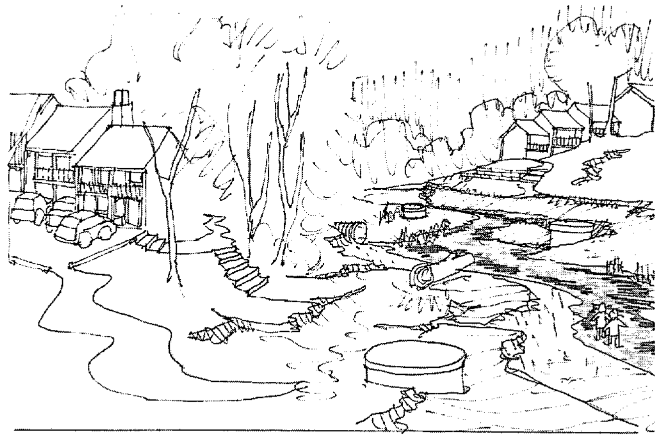
IT'S SEVERAL FEET ABOVE FLOOD LEVEL
... AND ITS BLUE GREEN POTENTIAL IS FABULOUS.

Figure 4

Figure 5



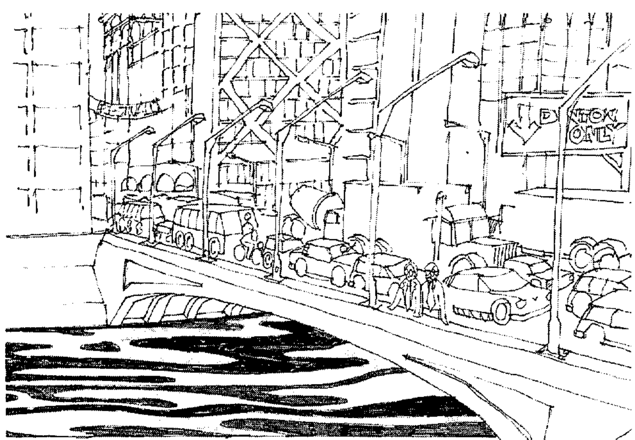
OK, I agree, ... "GURGLING CREEK" is perhaps a bit whimsical... but values and environmental improvement are felt over a much wider area than in cases where the riparian land has remained in private ownership. The continuity and natural fall of stream valleys make them ideal locations for trunk sewers, provided that installation can be carried out without excessive damage to the riparian habitat. Some of the cost of open space acquisition can be attributed to sewer easements and access easements. Access for cleanout of impoundments, for streambank stabilization and other maintenance necessary for the full realization of the Blue-Green concept is made possible by public tenure.



. . JOG BEFORE BREAKFAST. . . . . . WALK WITH THE CHILDREN TO SCHOOL ALONG THE CREEK . . . HEAR THE CALL OF WATERFOWL. . . . .

Figure 6

There is a great opportunity for urban hydrologists and open space planners to cooperate to establish open space systems, which, for any one of the above functions could hardly be justified. But as multifunctional Blue-Green systems, cost effectiveness dramatically improves. But as Earl Jones emphasized in 1967 "Unless arbitrary requirements are eliminated from urban drainage practice, the advantages and flexibility which open space planning makes feasible will be diminished or unrealized." Hopefully also there will be an end to the use of such dogmatic terms as "zero runoff" which lead to misunderstanding of the detention/storage concept for urban stormwater.



THIS IS OUR GREAT BLUE GREEN OPPORTUNITY.

Figure 7

When I spoke to Earl Jones recently, he told me that, looking back, he is increasingly aware that each case is unique, and that we must strive to understand the problems and opportunities of every situation to achieve an environment of lasting quality. He feels that the Blue-Green concept is valid at any scale from the design of a parking lot to a regional open space system and is valid for both urban and suburban areas. Finally a word of apology to Earl Jones for the cynicism of some of the cartoons, which I have shown this afternoon. They make fun, not of the Blue-Green Concept but of the failures of our past development practices which make Blue-Green so relevant today. Also I am sure that you will join me in wishing Earl Jones a speedy and complete recovery.

II. PLANNING, CONSTRUCTION AND OPERATION OF SYSTEMS

6

INVESTIGATION OF CONCRETE GRID PAVEMENTS

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Summary

The following research involves laboratory simulation and testing of typically installed concrete grid pavements. Five pavements exhibiting different physical characteristics were subjected to rainfall in order to collect runoff data. Coefficients of runoff and lag times are derived based on the following variables: (1) subgrade soil, (2) slope, (3) rainfall intensity, and (4) rainfall duration. The tentative runoff coefficients can provide the basis for design and implementation of the pavements as an alternative on-site technology within an overall stormwater management scheme. Future directions for investigations not directly related to hydrological characteristics are also included.

Background

Current directions in stormwater management emphasize the maintenance of pre-development runoff levels through on-site controls. Where traditional practices have utilized curbs and gutters to quickly convey stormwater to storm sewers, new approaches use roadside drainage swales to slow the velocity of drainage and allow for infiltration. New techniques emphasize the use of natural drainage systems with their low-velocity flow characteristics, and take advantage of opportunities for infiltration and groundwater recharge. Conventionally, parking lots have been designed to drain quickly. New goals also encourage the absorption or detention of stormwater in parking lots and on-street parking. Stormwater can be detained and allowed to either infiltrate into the soil or be slowly released after the storm event.

Concrete grid pavements have potential as a management practice for maintaining pre-development runoff levels by allowing for infiltration and groundwater recharge. These pavements can decrease the quantity of peak flow and increase lag time. Furthermore, this would minimize stream bank erosion and sedimentation due to increased runoff loads during and after storm events, thereby improving water quality. Concrete grid pavements have been used extensively in Europe and are presently available from manufacturers throughout the United States. On a properly compacted subgrade and properly designed and installed subbase, these pavements can support extremely heavy vehicular loads. Unfortunately, very little information is available concerning their hydrological characteristics either from the manufacturers or in the form of research data. Consequently, the cost effectiveness of the pavers cannot be estimated until their performance characteristics are delineated. We believe this is a key factor which inhibits the use of these pavements as an alternative technology for the reduction of stormwater runoff.

Equipment

Pavements were tested under a controlled setting at the Environmental Systems Laboratories of the College of Architecture and Urban Studies, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. The testing apparatus contained three major elements: the rain simulator, the testing bins and the water collection system.

Rain Simulator. The rain supply was provided by a rain simulator built and designed by the University's Laboratory Support Services. The rain simulator consisted of a single rotating irrigation nozzle selected because it produced a drop size and distribution similar to that of natural rainfall. The nozzle was rotated by a 1/15 horsepower motor geared at 2 rpm. The nozzle was situated approximately 14 feet above the pavement surface. Water pressure was governed by a pressure regulator and was displayed on a pressure gauge.

Testing Bins. The pavements were installed in three bins. Each bin was 6 feet long, 4 feet wide, and 3 feet deep. Their floors were constructed with 3/4 inch plywood glued to 2" by 10" joists, 6" on center. These platforms rested on two level steel I beams. The sides of the bins were constructed with 3/4 inch plywood glued to 2" by 4" studs, 9" on center. One side wall of each bin was removable to facilitate material extraction. The bins were waterproofed with 6 mil polyethelene film. Corrugated sheet metal was placed at the bottom of each bin to provide protection for the underlying waterproof plastic film. An inch and a half of cleaned gravel was spread over the corrugated sheet metal to facilitate subsurface drainage. Eleven to fourteen inches of soil were compacted manually with tampers in lifts of three inches. Soil compaction was tested with a hand-held penetrometer to document the level of compaction reached and assure uniformity. A minimum compressive strength of 3.5 tons per square foot was attained. Six inches of cleaned gravel were installed over each "subgrade." Aggregate size of this gravel ranged from 1" to 1/5". The depth of this "subbase" is typical for the pavements tested. Two inches of sand were added on top of the gravel. This sand was compacted and leveled to provide an adequate bearing surface for the pavers. The pavers were then installed. Voids were filled with top soil and sod. Turfgrass selection was made in consultation with Dr. Richard E. Schmidt of the University's Turfgrass Research Center. Mixtures of Kentucky Blue Grass sod were selected because of its durability under traffic and drought. See Figures 1 and 2 for illustrations of the test bins.

Water Collection System. The collection system gathered water which flowed off the surface of the pavers and percolated through the soil. The water flowed into covered channels and through hoses to calibrated tanks. From these tanks periodic measurements could be taken. Each test bin had two tanks: one to collect surface runoff and one for subsurface drainage. Figure 2 illustrates the water collection system for the bins. Pavement slopes were adjusted by lifting the bins at one end with hoists. The pavements were tested at three slope settings: 2%, 4%, and 7%. These slopes represent the range found in typical parking lots.

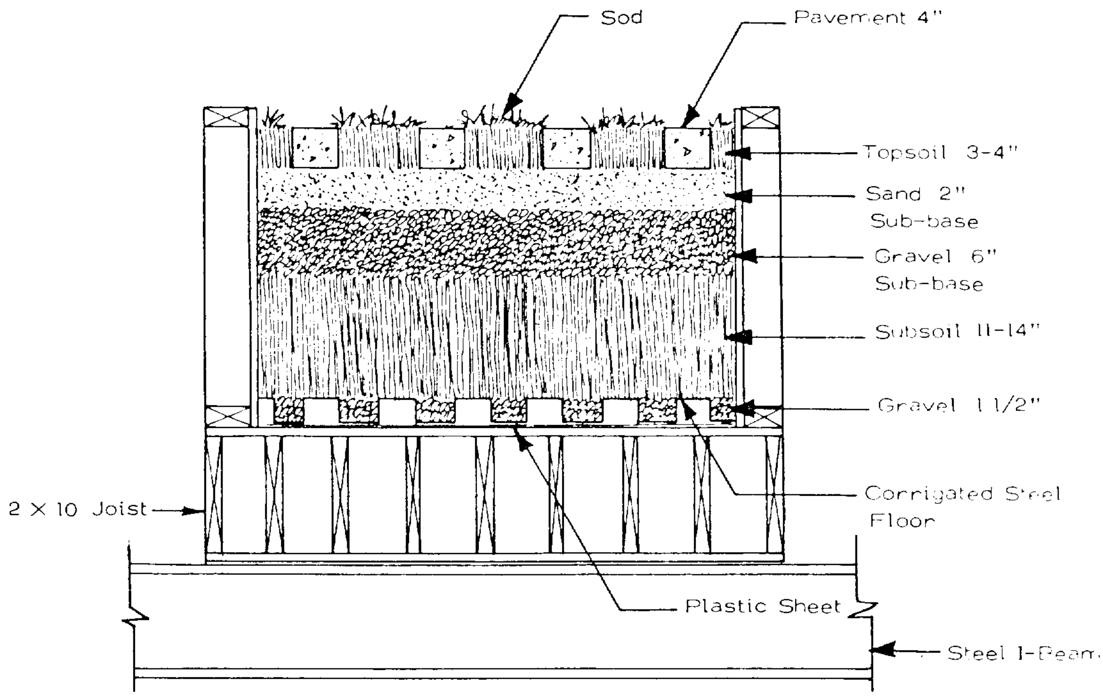


Figure 1
Typical Test Bin
Cross Section

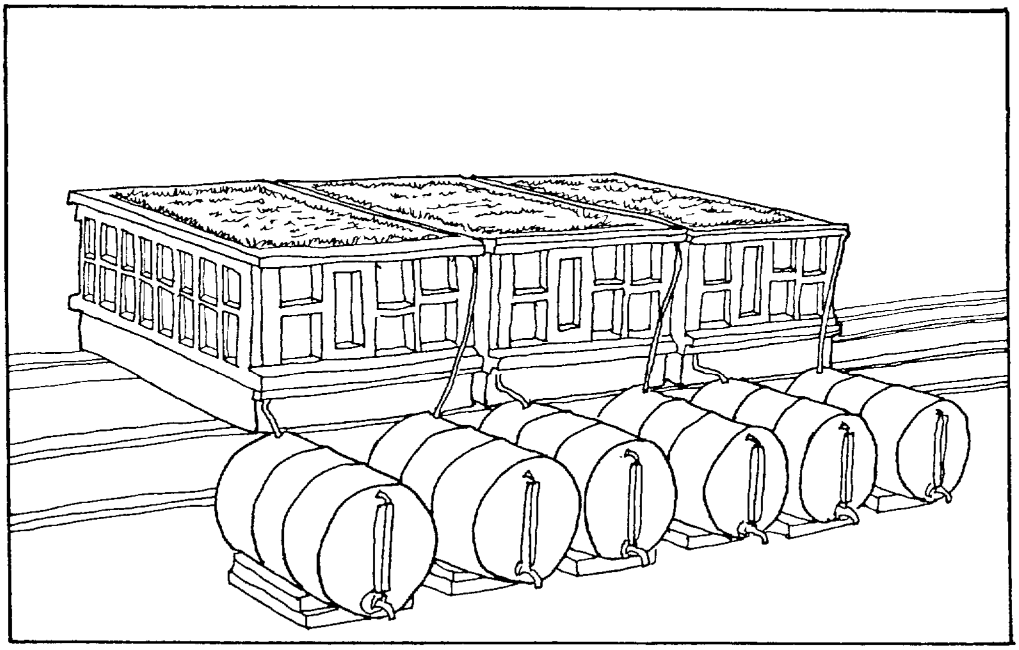


Figure 2
The Test Bins

Soils. Soils used in this investigation were obtained from University land close to the laboratory. The following soils were chosen for "subgrade": Bin #1, B horizon of Greensdale Silt Loam; Bin #2, B horizon of Groseclose; and Bin #3, C horizon of Frederick Silt Loam. For the purpose of this discussion we have named the Greensdale a "loose" soil, the Groseclose a "moderate" soil, and the Frederick Loam a "tight" soil. These three soils offered the greatest range of permeability values indigenous to this area and within close proximity to the laboratory. See Figure 3 for a comparison of hydraulic conductivity and permeability classes of each soil derived from soil tests.

Bulk Density. Soil bulk density is the ratio of mass to the bulk or volume of a soil sample. The maximum bulk densities were determined by using the Harvard Miniature Compaction Apparatus. Pavement manufacturers generally specify a compacted subgrade from 85 percent to 95 percent of the maximum dry density. Moisture content must be in a range of plus 4 percent or minus 2 percent of the optimum moisture content. Soils used in test bins were compacted to within the following percentages of their maximum dry bulk densities and within the following range of optimum moisture: Test Bin #1, Greensdale Silt, 83.2% maximum density at -2% optimum moisture; Test Bin #2, Groseclose, 78.8% maximum density at optimum moisture; and Test Bin #3, Frederick Silt Loam, 82% maximum density at +1.5% optimum moisture.

Classification of Pavers. The five different paver types were classified in two categories, lattice and castellated, as shown in Figures 4 and 5. Table 1 specifies the dimensions and weight of each pavement.

Table 1

Paver	% Open Area at Bottom	Weight (lbs)	Thickness inches	Length/Width inches
GRASSTONE Boiardi Prods.	34	59	3.625	23/17.25
TURFBLOCK Paver Systems, Inc. Wausau Tile	40	63	3.125	23.5/15.5
GRASSCRETE Bomanite Corp.	30	Poured in Place	4 & 6	24/24
MONOSLAB Grass Pavers, Ltd.	15	82	4.5	23.5/15.5
CHECKER BLOCK Hastings Co.	25	84	3.75	24/24

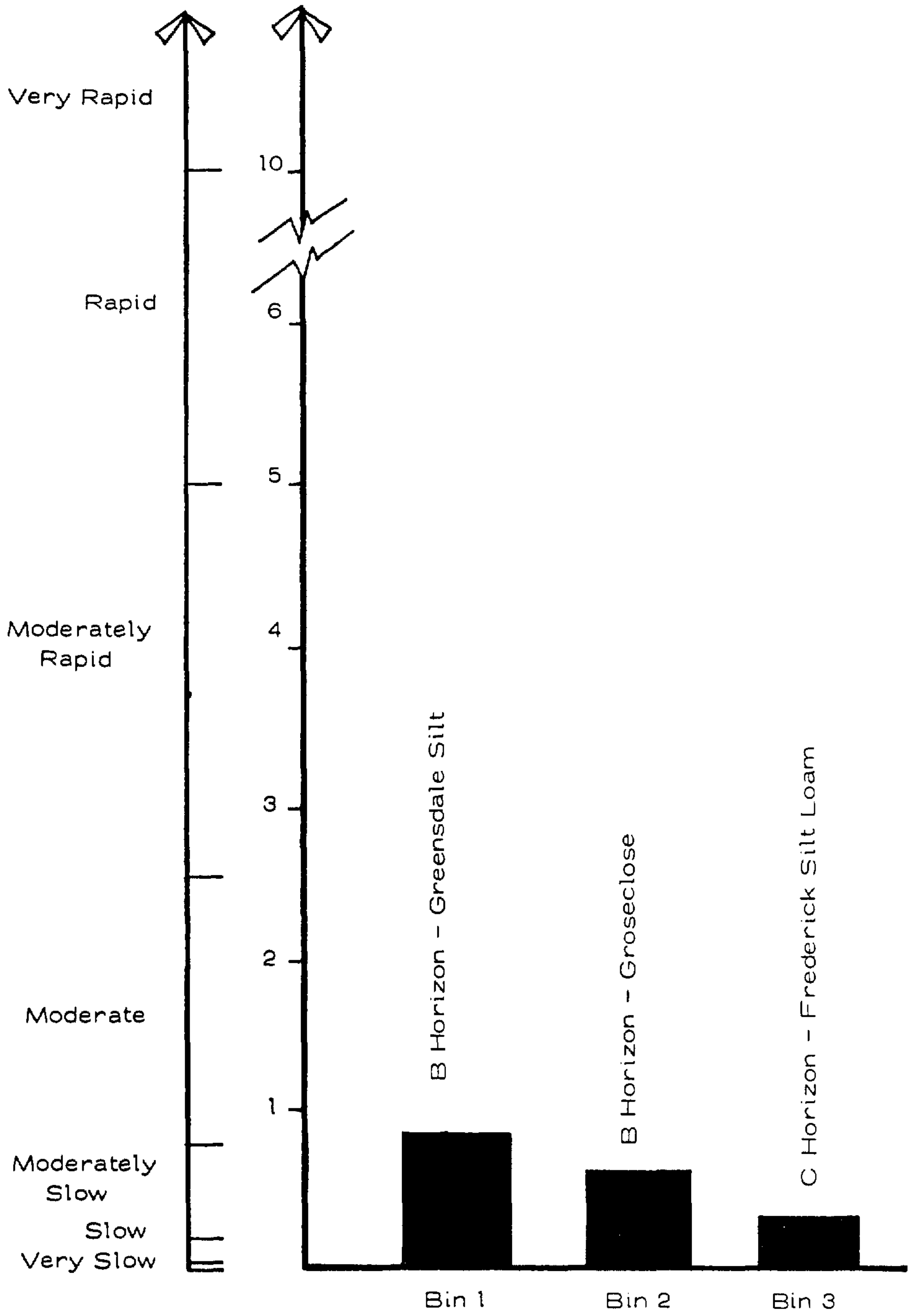
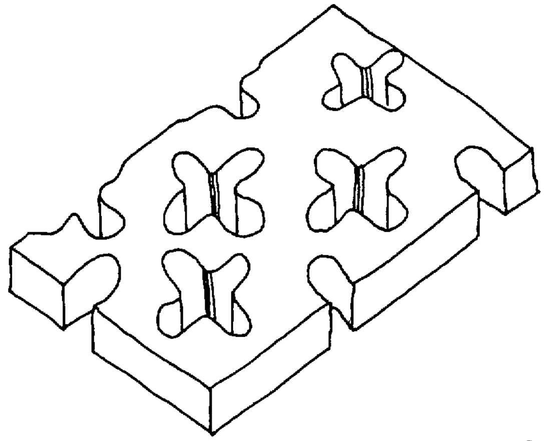
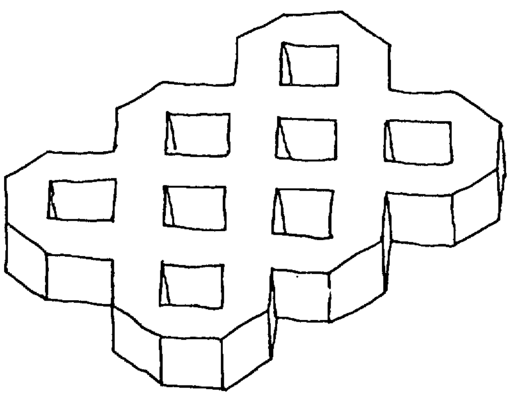


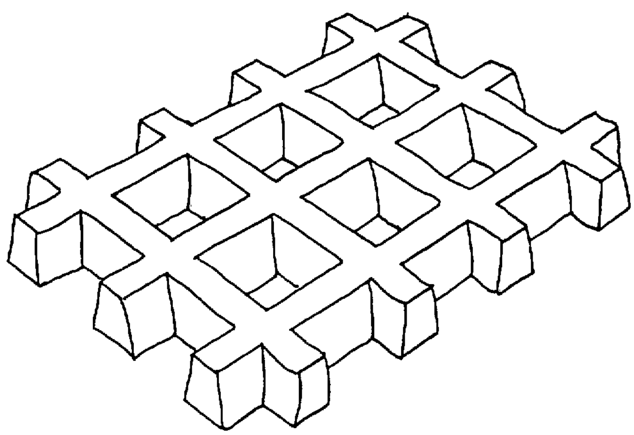
Figure 3
Comparison of Soil Hydraulic Conditions (in/hr)
to Permeability Classes



"Grasscrete" (Poured in Place)
by Bomanite Corp.

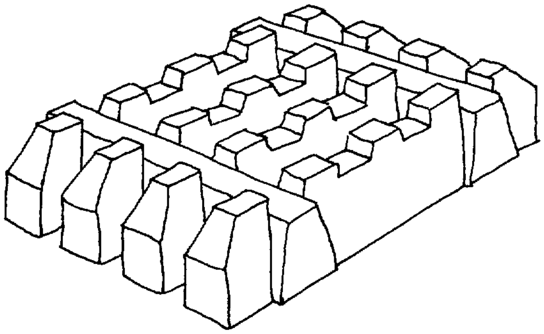


"Turfblock"
Paver Systems, Inc.
Wausau Tile

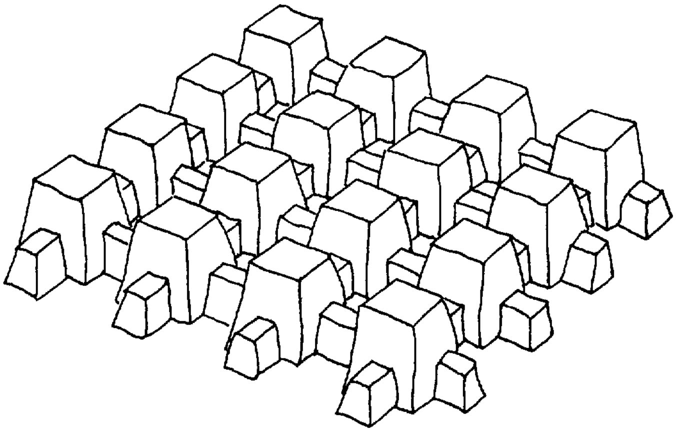


"Grasstone"
Boiardi Prods.

Figure 4
Lattice Grid Pavers



"Monoslab"
Grass Pavers, Ltd.



"Checker Block"
Hastings Co.

Figure 5
Castellated Grid Pavers

Procedure

Testing Procedure. There were three tests performed with each paver type under observation through one testing cycle (described in the next section). Monoslab, a castellated type paver comprised test one. Turfblock, a lattice type paver, comprised test two. Both of these pavers were tested in all three bins with the three subsoil types.

Our third test consisted of placing one of the three remaining paving systems--Grasstone, Check Block, and Grasscrete--in each of the bins. Grasstone was in bin #1 (loose soil), Grasscrete in bin #2 (moderate soil) and Checker Block in bin #3 (tight soil). Limited funds did not allow us to test each of these pavers on all three subsoil types. In spite of these constraints, we used the three remaining pavers to check the difference in the performance of the pavers used in test one and test two.

Testing Cycles. A testing cycle for each paver consisted of a two-hour rain followed by a two-hour drain period for three consecutive days. The rain simulator was activated for two hours and the surface runoff recorded. Subsurface drainage was monitored for another two hours after the rainfall period. The bins were then allowed to drain for 20 hours between each day of tests. During the first day the slope was set at 7%. Prior to starting the second and third days of tests, the slope was lowered to 4% and 2% respectively. Figure 6 charts the testing cycle for each pavement.

The day before the three test cycles the bins were saturated with rain at identical durations and slopes. Surface runoff and subsurface drainage were monitored to be sure that each bin was 100% saturated. The bins were allowed to drain 20 hours before commencing the next day's tests. This was done to insure that each subsoil had a baseline moisture content before gathering runoff test data. Surface runoff in gallons was recorded at 5 minute intervals during the rain periods. Subsurface drainage was recorded every 15 minutes during both the two-hour rain and two-hour drain periods.

Results

Results from Tests 1, 2, and 3 are displayed in Figures 7, 8 and 9. The performance curves at each slope setting are referenced against the 100% runoff curve for each bin. These curves show the total volume (gallons) of surface runoff plotted against time (duration of rainfall). Notice that the difference in lag time for each bin varies.

Coefficients of runoff were developed from the performance curves which are displayed in Table 2. Coefficients were developed for storm durations of 30, 60, 90 and 120 minutes.

Conclusions

1. Before commencing the tests we hypothesized that under the same rainfall, soil, and slope conditions, the paver with the highest percent of open area at the bottom should have the least amount of

Here a concrete grid paver is being placed
into a rain simulation bin to be tested.

DAY

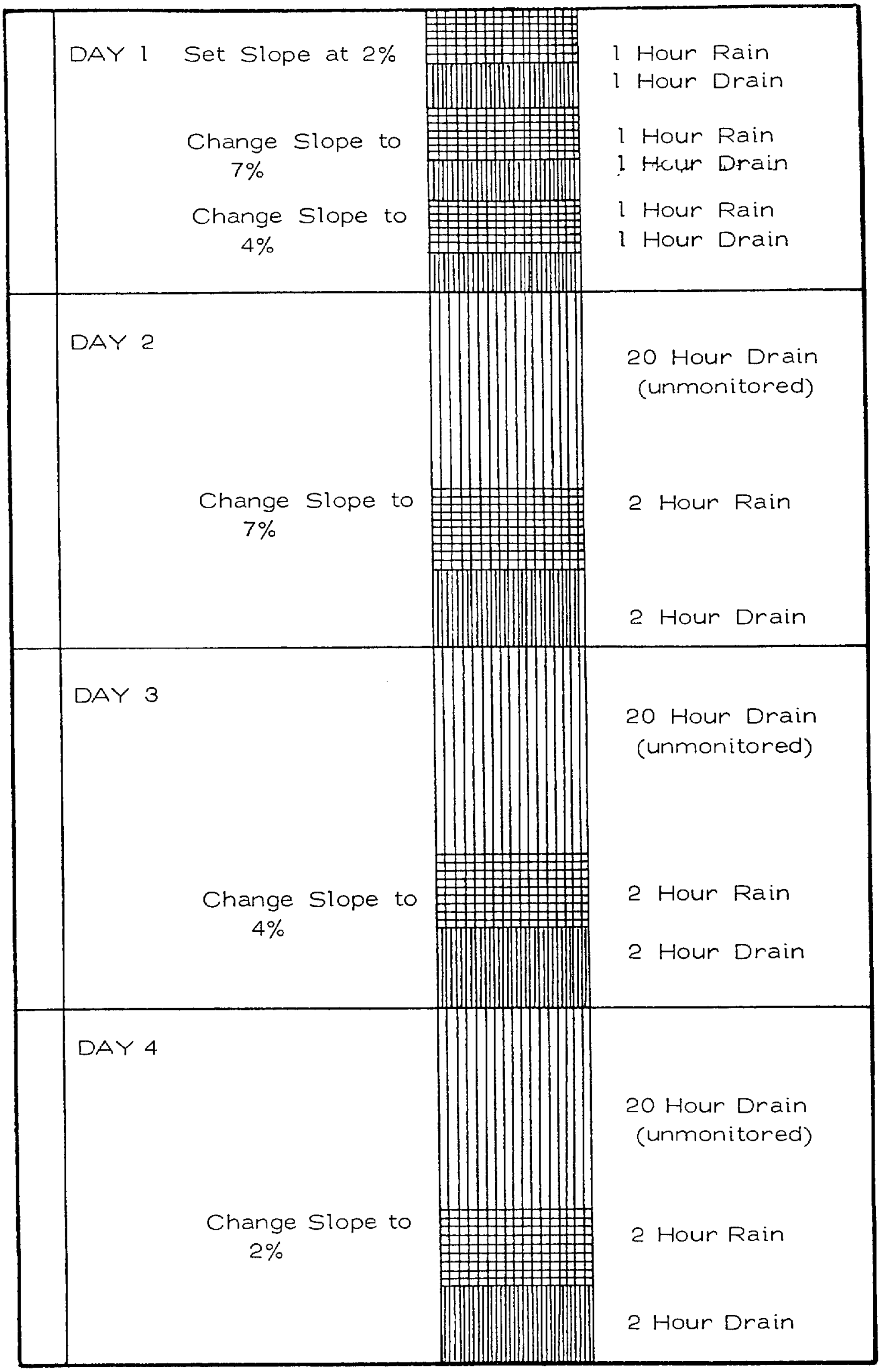
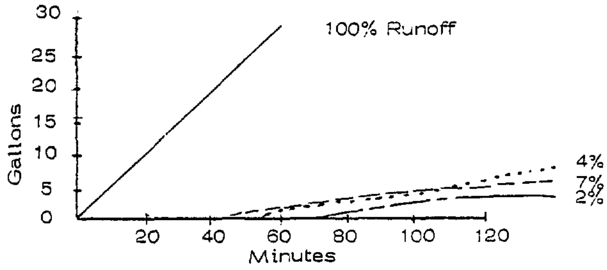
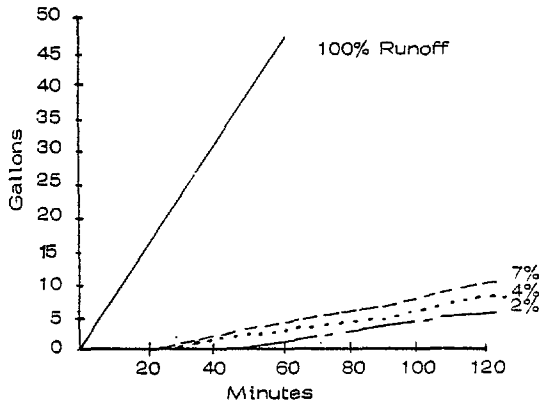


Figure 6: Testing Cycles for Each Pavement

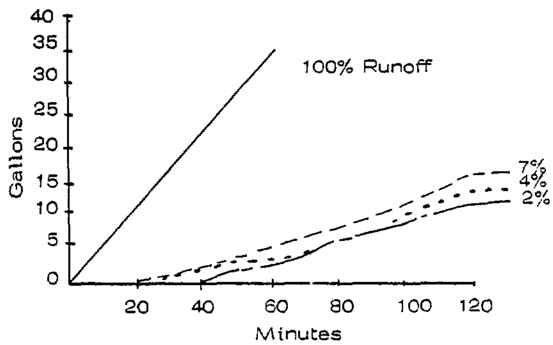
BIN #1
Loose Soil
I = 2.54 in/hr
K = 0.83 in/hr



BIN #2
Moderate Soil
I = 3.51 in/hr
K =0 .65 in/hr

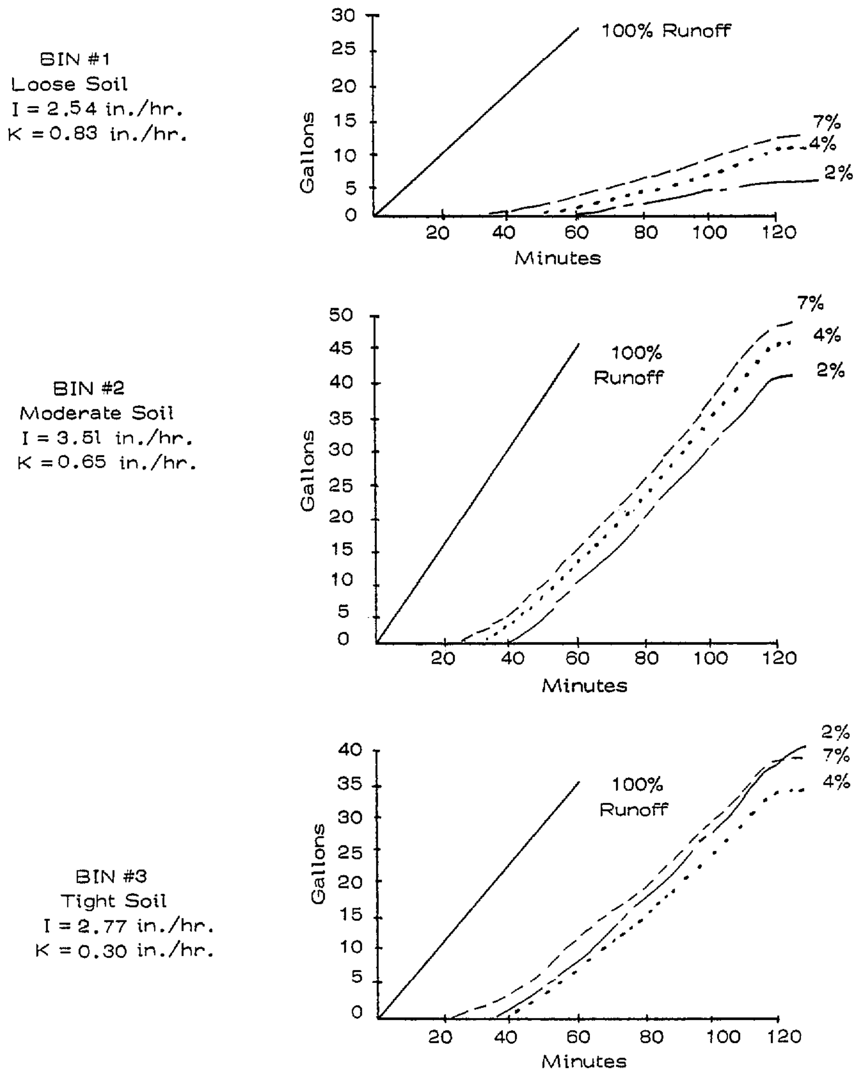


BIN #3
Tight Soil
I = 2.77 in/hr
K = 0.30 in/hr



Test 1: Runoff from MONOSLAB (Castellated type)
I = Rainfall Intensity
K = Hydraulic Conductivity of Subsoil

Figure 7
Test 1



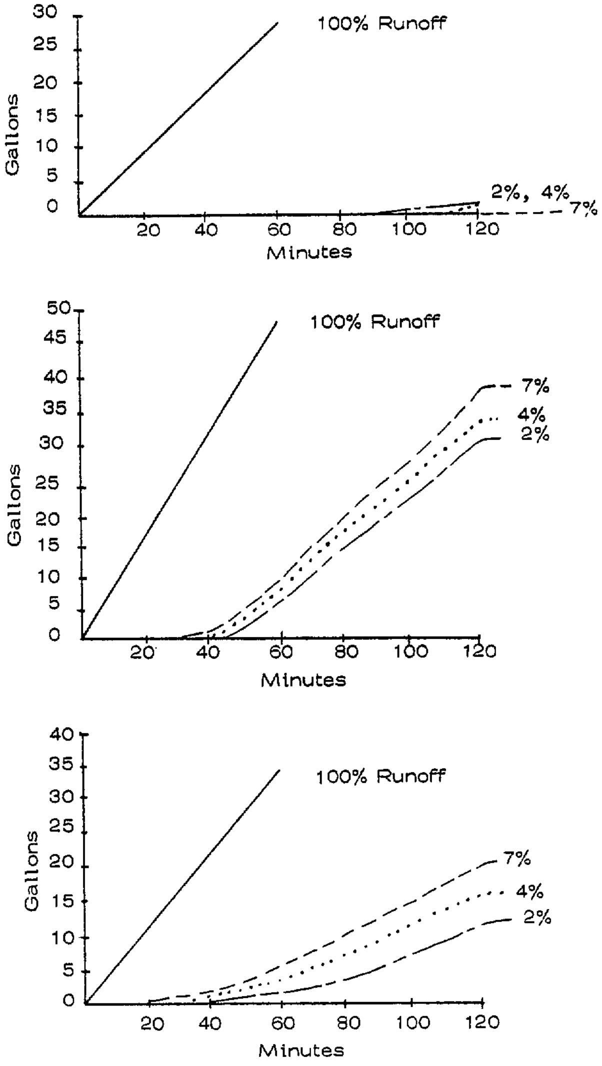
Test 2: Runoff from TURFBLOCK (lattice type)
I = Rainfall Intensity
K = Hydraulic Conductivity of Subsoil

Figure 8
Test 2

BIN #1
GRASSTONE
(Lattice Type)
Loose Soil
I = 2.34 in./hr.
K = 0.83 in./hr.

BIN #2
GRASSCRETE
(Lattice Type)
Moderate Soil
I = 4.15 in./hr.
K = 0.65 in./hr.

BIN #3
CHECKER BLOCK
(Castellated type)
Tight Soil
I = 2.97 in./hr.
K = 0.30 in./hr.



Test 3: Runoff from Pavers
(Note Lattice and Castellated Types)
I = Rainfall Intensity
K = Hydraulic Conductivity of Subsoil

Figure 9
Test 3

RUNOFF COEFFICIENTS FOR
CONCRETE GRID PAVEMENTS

	PAVING SYSTEM (Percent of Open Bottom Area)	Mins. of Rain-fall	BIN #1 Loose Soil Slope at:			BIN #2 Moderate Soil Slope at:			BIN #3 Tight Soil Slope at:		
			2%	4%	7%	2%	4%	7%	2%	4%	7%
TEST 1	MONOSLAB Grass Pavers, Ltd. (15%)	30	0	0	0	0	.09	.09	0	.09	.09
		60	0	.05	.05	.04	.06	.09	.09	.09	.12
		90	.05	.08	.09	.06	.07	.10	.15	.15	.20
		120	.07	.09	.10	.07	.09	.11	.17	.19	.23
TEST 2	TURFBLOCK Paver Systems, Inc. Wausau Tile (40%)	30	0	0	0	0	.01	.05	0	0	.10
		60	.01	.03	.09	.21	.28	.32	.23	.26	.36
		90	.06	.09	.16	.37	.37	.42	.37	.43	.45
		120	.09	.17	.20	.43	.48	.51	.48	.54	.56
TEST 1 & 2	Hydraulic Conductivity In./hr.		0.83			0.65			0.30		
	Rainfall Intensity In./hr.		2.54			3.51			2.77		
	Gallons/Minute		0.47			0.80			0.55		

	PAVING SYSTEM (Percent of Open Bottom Area)	Mins. of Rain-fall	BIN #1 Loose Soil Slope at:			BIN #2 Moderate Soil Slope at:			BIN #3 Tight Soil Slope at:		
			2%	4%	7%	2%	4%	7%	2%	4%	7%
TEST 3	CHECKER BLOCK Hastings Co. (25%)	30							0	0	.09
		60							.03	.07	.12
		90							.10	.16	.22
		120							.16	.21	.27
	GRASSCRETE Bomanite Corp. (30%)	30				.02	0	.02			
		60				.13	.15	.18			
		90				.23	.25	.28			
		120				.29	.31	.35			
	GRASSTONE Boiardi Prods. (34%)	30	0	0	0						
		60	0	0	0						
		90	0	0	0						
		120	.01	.01	0						
TEST 3	Hydraulic Conductivity In./hr.		0.83			0.65			0.30		
	Rainfall Intensity In./hr.		2.34			4.15			2.97		
	Gallons/Minute		0.48			0.88			0.60		

Table 2

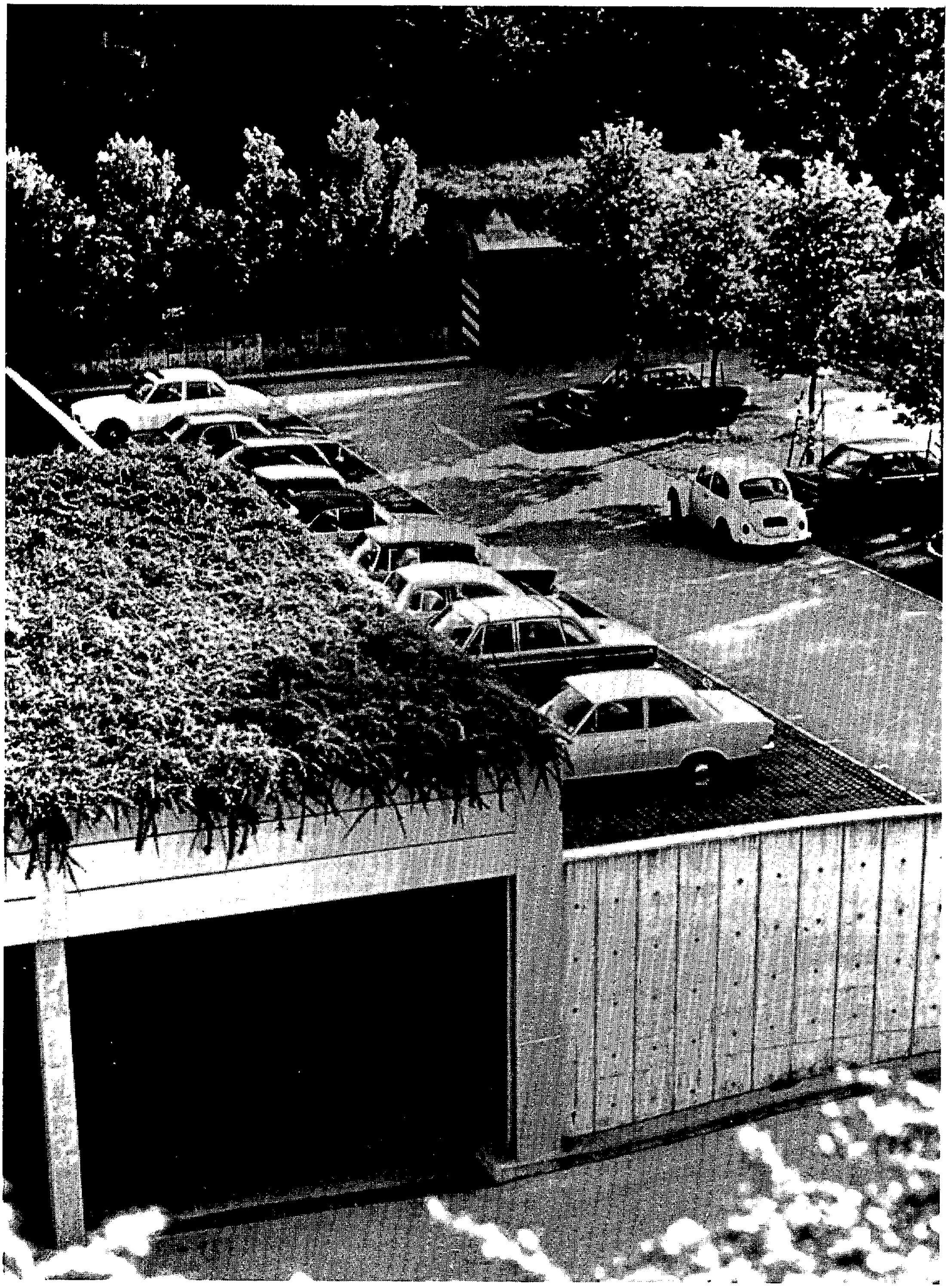
surface runoff. Turfblock, however, the paver with the highest percent of open area on the bottom, does not have the lowest runoff coefficients (note Table 2). In fact, Monoslab, with the lowest percent of bottom open area (15%), yielded lower coefficients when tested under similar conditions to Turfblock. Therefore, our hypothesis is challenged by this data. The ability of the paver to absorb and detain rainwater tends to be a function of its surface goemetry, not the percent of bottom open area.

2. An increase in slope (up to 7%) increases the coefficient of runoff regardless of paver type, subsoil type, or rainfall intensity. The greater the slope, the greater the runoff. Is there a "critical slope" at which the runoff coefficients approach that of asphalt or solid concrete paving? Is that critical slope different for each paver type? Is it different for each subsoil type on which the paver is placed? A potential area of investigation is in studying the relationship of the orientation (in plan) of a paver to a given slope. The five pavers tested were placed longitudinally in the bins. Would there be a difference in runoff if these pavers were placed askew at a 45^{o} angle to the slope? Would there be more or less of a difference in percentage of runoff between the two categories of pavers? The difference, if one exists, may lead to more sensitive and effective application.

3. Subsoil type, as expressed by hydraulic conductivity, has an effect on the coefficient of runoff. Lower hydraulic conductivity of the subsoil yields a higher coefficient of runoff, especially on steeper slopes. This is consistent unless the rainfall intensity approximates the hydraulic conductivity of the subsoil. When this occurs, little or no surface runoff is produced. Note Grasstone in Test 3, Table 2. The hydraulic conductivity of the subsoil approaches the rainfall intensity on this bin; hence, no runoff.

Future Directions

Beyond Hydrological Research. In addition to the ability to reduce runoff, the pavements should have the following potential environmental benefits: (a) nonpoint pollution reduction, (b) glare reduction, (c) sound absorption, and (d) microclimatic temperature reduction. These aspects are favorable by-products of the pavement's function of runoff reduction. It is possible to also consider redesigning the configuration of the pavements to achieve better ergonomic aspects. Improvements could produce a surface compatible with walking, bicycling and use by handicapped adults or children. Figure 10 indicates that the runoff coefficients derived in this investigation are sufficiently lower than standard asphalt and concrete pavements. In view of this observation, these pavements could actually be less expensive to install than conventional pavements when a corresponding reduction of storm sewer pipe sizes and lengths are taken into account. In addition, the rising cost of petroleum-based asphalt is diminishing the price differences between conventional pavement and concrete grid pavements.



Porous grid pavers with grass cover and vegetated rooftop detention form a attractive and well-maintained design solution in Stuttgart, West Germany.

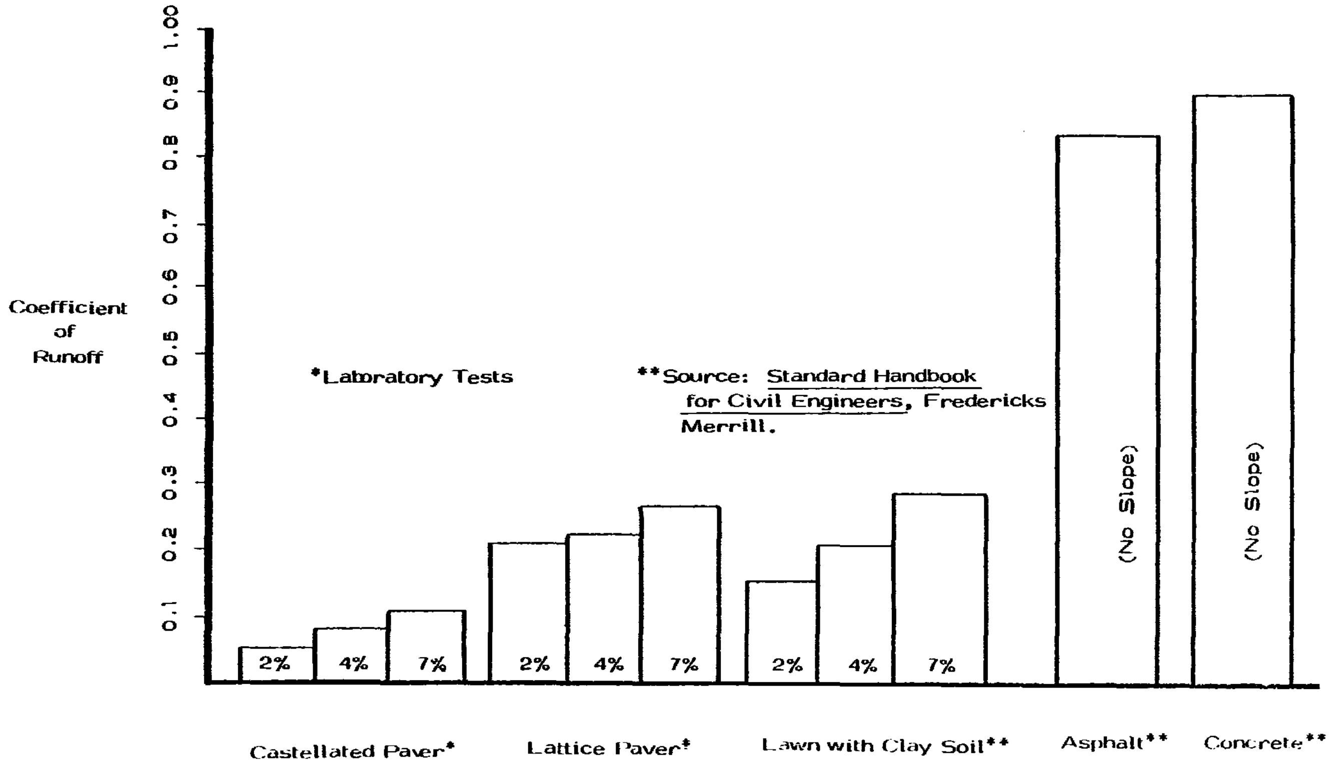


Figure 10
Comparison of Runoff Coefficients of Concrete
Grid Pavements to Other Urban Surfaces

We would like to thank the following concrete grid pavement manufacturers for their contribution of funds and pavers to this research effort.

Monoslab
Grass Pavers Ltd.
3807 Crooks Road
Royal Oak, MI 48073

Turfblock
Paver Systems, Inc.
1800 4th Avenue, North
P.O. Box 1221
Lake Worth, FL 33460

Turfblock
Wausau Tile
P. O. Box 1520
Wausau, WI 54401

Grasscrete
Bomanite Corporation
81 Encina Avenue
Palo Alto, CA 94301

Checker Block
Hastings Pavement Co., Inc.
410 Lakeville Road
Lake Success, NY 11040

Grasstone
Boiardi Products Corp.
211 East 43rd Street
New York, NY 10017

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7

POROUS PAVING

L. FIELDING HOWE, JR.

Landscape Architect, Merion Station, PA

The effects of urbanization and changes in our way of life over the last 50 years have resulted in huge increases in the area of paved surfaces, especially of parking lots. These increases have resulted in flooding problems and decreased the ground water. Grave strains placed upon our water supply and sewerage systems are indicative of the increasing demands being made on the environment.

Traditional drainage practice has been to remove runoff from sites as rapidly as possible. However, we have come to realize that stormwater is a valuable part of the total water resource and can often be reused, for instance in the replenishment of ground water. Some measures for stormwater management are not well received by developers or property owners. Holding ponds reduce the developable site area, drainage and access easements restrict the use of one site and the homeowner may be saddled with a maintenance responsibility for stormwater systems with liability in case of default.

It was in response to these problems that the Franklin Institute of Philadelphia, working under a grant from the Environmental Protection Agency, developed porous paving. The concept of porous pavement is to allow rain water to penetrate through a porous asphalt surface into a crushed stone base course reservoir which temporarily stores the water. The stored water is then absorbed by the soil and returned to the water table. This is expressed by the simple hydrologic relationship: INFLOW - OUTFLOW = STORAGE.

The total design thickness must be chosen in light of each of the following factors: soil support, frost penetration, traffic load, (as in conventional paving) and the reservoir capacity to meet the requirements for stormwater management. The criteria for estimating the reservoir for capacity are: soil permeability, maximum storm intensity and frequency, allowable runoff, and slope.

Soil maps of the site are helpful to determine soil classification and soil hydrologic characteristics including infiltration rate. It is of primary importance to the design of the pavement that the permeability of each soil layer is tested by drilling and coring to a depth of 15-20 feet in a grid pattern. Percolation tests are also conducted in the same area to determine absorption rates expressed in inches per hour. The weighted average of the result of each test pit is used for design and should be 1/4 inch per hour or more. Design storm frequency selected should be viewed as a weighted engineering judgment being consistent with the ultimate land use, allowable risk and within the capacity of local systems to receive the rate of runoff. There should never be surface runoff from a well-designed porous pavement unless the design storm is exceeded.

The reservoir formed by the base course of the porous pavement can be used as a detention basin for the pavement area or for part or all of the rest of the site. For this purpose, it is necessary to know the runoff BEFORE construction and compare this with the runoff AFTER construction. Knowing the increase in runoff to be expected from construction, the thickness of the base course required can be calculated from the "Volume of Storage" table in the Porous Pavement Design Manual of The Franklin Institute Press.

If the site is to be sloped and the soil percolates water slowly, additional features can be designed to keep the base reservoir from flooding without changing the basic characteristic of retaining water on site. One of these drainage augmentations could be a French well to conduct water through a poor stratum of soil to better soil conditions. If a ditch is nearby, the base course can be extended downhill all the way out to "daylight" to facilitate drainage. A drain field can be used sized on the BEFORE construction runoff, discharging into local storm-water systems. The base course reservoir is made up with 2 inch diameter crushed stone lightly packed with a void volume in the order of 40%. On slopes over 1 1/2%, the base should be thicker at the lower end to hold water draining from the higher levels. In other words, to optimize the base course reservoir capacity the subsoil should be continuously exposed to water during rainfall.

During the construction phase for porous paving, special care must be taken to prevent sediment from getting into the reservoir base course.

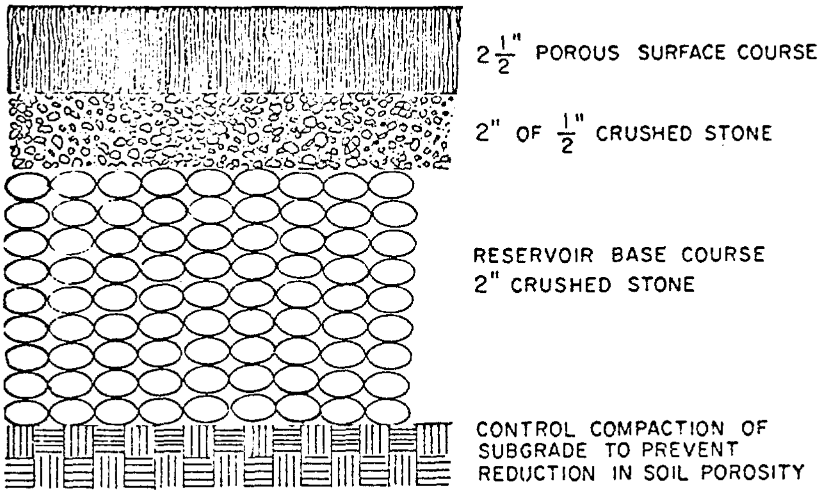
Cold temperatures do not damage porous pavement as long as the soil under it is non-heaving and drains below the frost penetration line for paving which is 10 to 15 inches in Philadelphia. This is a general requirement for conventional paving and a necessity for porous paving.

Porous pavement is a good heat insulator, not a conductor. With a surface temperature of 32 degrees F, it could easily take 24 hours to freeze throughout. No harm is anticipated with ice heave since the connecting void space among the rocks is in the order of 40% which allows room for freeze-thaw without undue stress on the high porosity surface materials. As soon as the sun hits the black porous asphalt surface, even with ice on it, it melts the ice touching it and water will drain through the pores, eliminating the refreezing that forms ice.

Soil under porous pavement can clean the water draining through since aerobic bacteria can attack organics causing their disintegration. The degree of purification depends on the soil and its supply of air and water, temperature, length of percolation path, and the nature of the pollutant.

Porous asphalt paving is not perfect and during the six years period of use we have had the following problems: superficial dirt will not plug the pavement but dirt and leaves cannot be allowed to accumulate on the surface to be ground in by traffic or it will close the surface pores; very heavy traffic, especially during construction, can break down the surface and close the pores; in areas of concentrated traffic at parking lot toll gates, the power steering of wheels in a stationary position will rupture the porous surface resulting in complete reduction of surface porosity.

In computing cost of construction, you have to keep in ming that it is saving the cost of a whole drainage system. All I can say is, try it, you may like it.



SECTION OF POROUS ASPHALT PAVING

Reprinted from "Porous Pavement" by Edmund Thelen and L. Fielding Howe, The Franklin Institute Press, Boxx 2266, Philadelphia, Pennsylvania 19103.

8

COOPERATION FOR RECREATION AND STREAMBANK RETENTION - THE TIOGA COUNTY EXPERIENCE

PATRICK SMYTH AND JEFFREY E. BARNES

Tioga County Planning Board, Oswego, NY

The streambank erosion rate contributes over 70 tons of sediment per bank mile in New York State. Results of grassroot sampling in 1978 suggest that streambank erosion/sedimentation is a number one priority in New York's Southern Tier counties. Tioga County, New York has taken the initiative in instituting an improvement program on several segments of a major stream system - the East and West Branches of Owego Creek. As early as 1968, the Directors of the Tioga County Soil and Water Conservation District (SWCD) placed a priority on an action-oriented program designed to obtain results in streambank retention, improve trout stream habitat and to gain better access to fishing as a recreation form. This action-oriented program recognized that the vagaries of a natural stream could wreak havoc on various land resources and could cause many dollars worth of damage not only to man's economic environment but also to his natural environment. Though not spectacular in scope, the following documents one county's work in addressing this problem.

Early in 1970, a local sportsman's association called the District's attention to an erosion problem on the West Branch of the Owego Creek. This tributary of the Susquehanna River is one of several trout streams in Tioga County and forms a natural border in its northern reaches with Tompkins County. This association was concerned about the creek relative to trout fishing and since the New York State Department of Environmental Conservation (DEC) stocks the stream on a regular basis, their concern was well-warranted. Every spring the creek breaks out of its regular channel, forming side channels, spreading across farm land, cutting away rear yards of residential lots and generally becoming what a trout stream ought not to be -- a shallow, warm and slow moving body of water. This stream is made to order for a project for streambank retention.

There are several programs existent in New York State that makes this project work. The most important is Section 11-0501 of the Environmental Conservation Law which allows the Department of Environmental Conservation to enter into cooperative agreements with private landowners. The DEC can furnish the landowner with technical service, trees and shrubs from State nurseries and technical assistance in the form of labor and materials to carry out conservation practices on private land. The landowner in return has to keep the land open to the public for hunting, fishing and other related recreational activity.

The DEC is also pursuing the purchase of easements for fishing rights of way. This section of the law, better known as the Fish and Wildlife Management Act, is very important to our project stream since it runs through predominantly private land.

Since the title of this expose is cooperation, it behooves one to move in that direction. Without going into a long dissertation on streambank retention techniques, Figure 1 should suffice to at least allude to the kinds of ways one can construct bank retention devices. To construct such devices, one needs entry to private property, the materials with which to do the job, the technical expertise on where and how to construct and the money to pay for the required labor. The coordination of this task is not impossible if there is a dedication to results. In Tioga County, dedication was the long suit.

The project was initiated in 1970 under the Resource Conservation and Development Program (RC&D), administration for which falls to the Soil Conservation Service. Together with the SWCD, the project was launched. As was mentioned above, the importance of NYSDEC's involvement cannot be minimized. This gave access to private property, and the materials and technical expertise. Technical expertise came from State biologists designing the correct environments for a trout fishery. Materials like logs, spikes, wire mesh, plantings, and stone came from DEC sources as well as some local town resources. Utilizing DEC experts, the County Soil and Water Conservation District coordinated with the Soil Conservation Service to oversee and manage the project. Once the design and location of retention devices were finalized, it remained to find labor with a minimum of monetary resource. In the present case, Tioga County's SWCD did not have to use any of its own funds. The first source of labor came through the federally funded Neighborhood Youth Corp., which in Tioga County is known as the Tioga Opportunity Program (TOP). The labor supply was augmented by utilizing inmates of Camp Austin MacCormick, a New York State Youth Rehabilitation Center (part of the NYS Corrections System) located in nearby Tompkins County. Since the project area was only a short drive from this facility, it made it convenient for this facilities administrators to tie into this project. Inmates normally are utilized in projects on state lands and cannot work on private lands unless the state has some sort of easement or agreement for public use.

After the flooding associated with Hurricane Agnes in 1972, the county received funds from the Federal Public Employment Program (PEP) to hire people for emergency work on streams throughout the county. In addition to clearing streams of debris, crews were employed to work on structures in the project area into the fall of 1972. PEP provided the funds for crew supervision through 1973. Even with using federal funding sources, labor was not wanting. Local Boy Scout troops volunteered to work, thus providing another benefit -- education in stream engineering and economics as well as environmental education.

A work crew must have materials and equipment with which to work. Most of the Materials were provided by the NYSDEC. Standard materials include northern white cedar logs or creosote treated red pine, assorted spikes, 1-inch and 2-inch wire mesh screening, galvanized fence staples

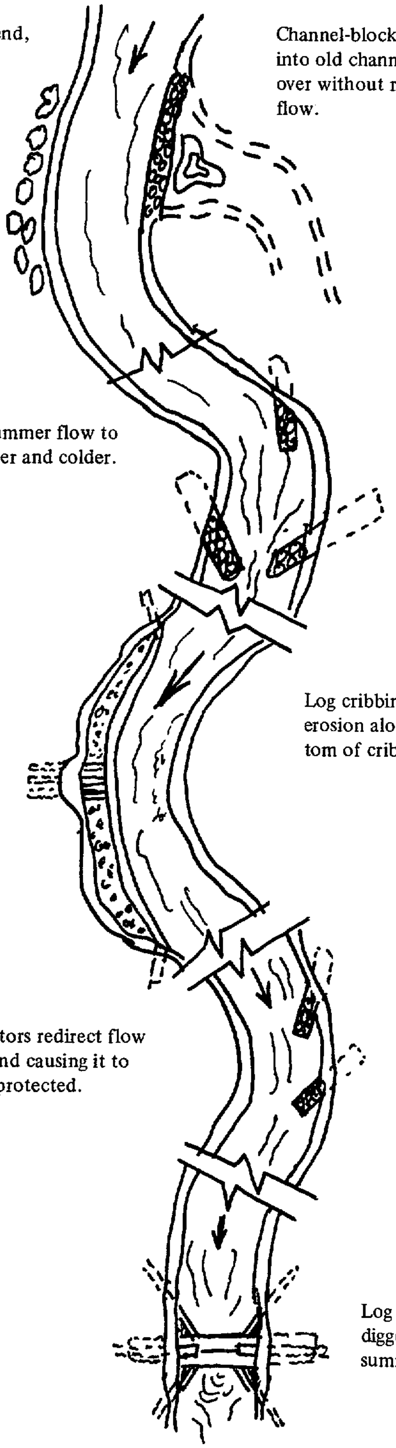

Willow plantings hold bank at bend, and give shade to trout.
Channel-blocker prevents relocation of stream into old channel way. Flood current passes over without reopening channel to permanent flow.
Twin log crib deflectors direct summer flow to center of channel making it deeper and colder.
Log cribbing, filled with stone prevents further erosion along critical areas of bank. Plank bottom of crib gives shade and cover to trout.
Cantilever log support, installed back into bank where crib spans over long pool.
Series of gabion deflectors redirect flow to center of channel, and causing it to deepen, while bank is protected.
Log and stone center drop dam (pool digger) creates deep pool and directs summer flow.

Fig. 1

and 3/4-inch by 8 foot reinforcing rods. Assorted other heavy equipment like bulldozers and backhoes were also provided by the Department. Occasionally, Town Highway trucks hauled fill materials.

The majority of structures built and that will be built provide a function of maintaining a narrow streambed which also reduces flooding and bank erosion. Because the channel is deeper, trout habitat is improved. Creation of pools and shaded areas decrease the water temperature. The NYSDEC provides willow and dogwood seedlings from its nurseries for use in stream retention areas. These have been used judiciously throughout the project area. The various crews working in the project area have had good fortune in installing their devices. Flood levels ranging between two and four feet above these structures have rendered no appreciable damage and all are functioning well today with routine maintenance.

Since 1975 work has moved to the East Branch of Owego Creek and some crews have developed or are developing ancillary functions like parking areas and trail access for fishermen on the West Branch. From 1975 through 1979, the Youth Conservation Corp. has supplied an average of 28 crew people during an 8-week summer session. The Comprehensive Employment Training Act (CETA) has also contributed a goodly share, averaging about 12 individuals per year for the same period.

The on-going stream improvement project has annually utilized the joint planning efforts of the DEC fishery biologists and local soil and water conservation technicians to make the upper East and West Branches of Owego Creek a more viable stream in terms of trout hold-over and carrying capacity. Also, former sources of erosion and sedimentation have been stifled. Flooding and flood damage has also been reduced. This seemingly minor project, carried on here in Tioga County, New York, when coupled with other efforts that might duplicate its effort, will eventually impact the people of the Chesapeake. What little is done in the broad headwater region of the Susquehanna can only have benefits to all locally and in the place where our water reaches the Atlantic.

9

BEST MANAGEMENT PRACTICES IN THE 1978 NEEDS SURVEY

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ABSTRACT

The U.S. EPA is mandated to submit to Congress a biennial Needs Survey report, which estimates the cost of constructing publicly-owned treatment facilities to ensure fishable and swimmable waters in the United States by 1983. The 1978 EPA Needs Survey report estimates the cost for controlling combined sewer overflow (CSO) at $25.7 billion and the cost for controlling pollution from urban stormwater runoff (SWR) at $61.7 billion, both in January 1978 dollars. These cost estimates are based in part on a site-specific receiving water impact analysis of 10 combined sewer sites and 5 separate storm-sewered sites across the nation. Two relatively independent phases were conducted to develop information related to receiving water impacts from CSO and SWR and information related to cost-effective combinations of control alternatives for these sources of pollution. Phase I utilized continuous hydrologic simulation of the total urban environment to estimate the required stormwater pollution removal to obtain beneficial receiving water uses, and Phase II entailed production theory and marginal cost analysis to identify a cost-effective combination of streetsweeping and combined sewer flushing in series with storage/treatment to obtain any desired level of stormwater pollution removal from combined or separately sewered watersheds. Phase II results can be readily adapted to site-specific cultural and social values when a decision must be made whether to spend public monies for increasing beneficial receiving water uses.

The results of the economic analyses indicate that it is generally more cost-effective to employ a mix of control alternatives rather than a single technology. Furthermore, best management practices (i.e., streetsweeping and combined sewer flushing) are generally most useful when overall pollutant removal requirements are low, whereas storage/treatment systems are most useful when overall removal requirements are high.

INTRODUCTION

The Federal Water Pollution Control Act, as amended in 1972, marked a significant shift in our nation's approach to administering water pollution abatement programs. Prior to 1972, effluent from point sources of pollution was regulated indirectly by monitoring receiving water standards. The new approach mandates that specific minimum treatment technologies be applied at all point sources of pollution to obtain certain effluent characteristics. If receiving water goals can not be met when these effluent limitations are in effect, additional point and/or nonpoint source controls may be required. When the decision is made to spend public monies for additional pollution controls, the cost effectiveness of controlling both point and nonpoint sources of pollution should be determined. Therefore, water quality problems are becoming more complex to solve and require new planning approaches which consider the dynamic nature of nonpoint source pollution and best management practices which control them.

This paper discusses the approach used in the 1978 EPA Needs Survey (Wycoff, Scholl, and Kissoon, 1979) to estimate the capital cost of controlling combined sewer overflow (CSO) and urban stormwater runoff (SWR) in the United States. The following sections present a background of the Needs Survey, the control technologies considered, the methodology for determining least-costly combinations of control technologies, and the results as related to the application of best management practices to nonpoint source pollution control.

BACKGROUND OF THE NEEDS SURVEY

The U.S. EPA is mandated to submit to Congress a biennial Needs Survey report, which estimates the cost of constructing publicly owned treatment facilities to ensure fishable and swimmable waters in the United States by 1983. The first comprehensive Needs Survey in 1973, which focused on the needs to achieve the 1977 requirements of PL 92-500, determined the needs for five categories: I--Secondary Treatment, II--More Stringent Treatment, III--Infiltration/Inflow Correction, IVa--New Interceptor Sewers, IVb--New Collector Sewers, and V--Combined Sewer Overflow Correction. The 1973 estimate of CSO needs in 1978 dollars was $17.9 billion. Needs for urban stormwater control and major sewer rehabilitation were not included in this Needs Survey.

The 1974 Needs Survey divided Category III into IIIa--Infiltration/Inflow Correction and IIIb--Major Sewer System Rehabilitation and added Category VI--Treatment and/or Control of Urban Stormwater Runoff. The 1974 estimate of Categories V and VI needs in 1978 dollars was $43.8 billion and $331.2 billion, respectively. EPA provided specific guidance to the states and municipalities in 1974 for Categories I and IV; however, the limited guidance provided for Categories V and VI resulted in widely varying methods and assumptions. These variations in methods, assumptions, and results identified a need for a uniform technique to be applied nationwide.

Under authority of Section 315 of PL 92-500, the National Commission on Water Quality (NCWQ) developed an independent survey to estimate the costs of achieving the requirements of PL 92-500 for publicly owned treatment works. The NCWQ survey resulted in a range of cost estimates for control of pollution from combined sewer overflow and urban stormwater runoff, depending on the level of control achieved. This range in 1978 dollars was $5.9 billion to $96.4 billion for Category V and $64.8 billion to $491.8 billion for Category VI. The NCWQ investigation applied a uniform set of assumptions, criteria, and methods nationwide and therefore did correct some of the deficiencies of the 1974 Needs Survey.

In 1976, the EPA elected to conduct the entire Needs Survey under contract to several consultants. Like the NCWQ study, the 1976 Needs Survey for Categories V and VI also employed a uniform set of assumptions, criteria, and methods to develop the nationwide estimates. However, unlike previous surveys, the 1976 needs estimates for Categories V and VI were developed for three different receiving water quality objectives: (1) aesthetics, (2) fish and wildlife, and (3) recreation. The recreation objective is the only one of the three considered which will fully meet the requirements and goals of PL 92-500. Therefore, the recreation objective cost estimates are the only needs reported to Congress. The 1976 recreation objective estimate for Categories V and VI needs in 1978 dollars was $21.2 billion and $62.8 billion, respectively.

The 1978 Needs Survey was conducted in a manner similar to the 1976 survey, with the objective of updating and improving the estimates. The major improvements to Category V and VI estimates in the 1978 survey were: (1) development of probabilistic wet-weather receiving water quality criteria, (2) development and application of a continuous stochastic urban runoff and receiving water response simulation model to estimate pollutant removal benefits at selected study sites, and (3) application of production theory and marginal cost analysis to determine the least costly mix of structural and nonstructural pollution abatement controls. The 1978 recreation objective estimate of Categories V and VI needs was $25.7 billion and $61.7 billion, respectively. Table 1 compares 1978 survey results to previous estimates. (A summary of results for the 1978 Needs Survey is presented in the May 1979 Journal of Water Pollution Control Federation).

TECHNOLOGIES CONSIDERED

Best management practices (BMP's) to control the accumulation of pollutants on an urban watershed should not be considered as independent pollution control alternatives but should be considered part of a total pollution control plan. They are likely to play an increasingly important role in maintaining and protecting the quality of our nation's water resources.

Alternative technologies for the control of CSO and urban stormwater runoff can be categorized into three types: (1) source controls, (2) collection system controls, and (3) treatment facilities. Source

Table 1
Comparison of Nationwide Capital Cost
Estimates for the Control of Pollution from
Combined Sewer Overflow and Urban Stormwater Runoff

A. Combined Sewer Overflow (Category V)

	Capital Cost in Billions of January 1978 Dollars
1973 Needs Survey	17.9
1974 Needs Survey	43.8
NCWQ Report	5.9 - 96.4

	Aesthetics Objective	Fish and Wildlife Objective	Recreation Objective
1976 Needs Survey	6.5	14.0	21.2
1978 Needs Survey	2.0	10.9	25.7

B. Urban Stormwater Runoff (Category VI)

	Capital Cost in Billions of January 1978 Dollars
1973 Needs Survey	--
1974 Needs Survey	331.2
NCWQ Report	64.8 - 491.8

	Aesthetics Objective	Fish and Wildlife Objective	Recreation Objective
1976 Needs Survey[a]	23.7	58.7	62.8
1978 Needs Survey[a]	1.4	29.2	61.7

[a]Both the 1976 and 1978 Category VI needs estimates consider urban runoff controls for census-defined Urbanized Areas only.

controls considered were streetsweeping, combined sewer flushing, and catch basin cleaning. Catch basin cleaning was eliminated since a national survey (Lager, et al., 1977) indicated it is not a feasible pollution control alternative due to high cost and low removals. Collection system controls considered were flow reduction, sewer separation, and inline storage. Since capital costs of these control systems are site specific, they could not be evaluated on a national basis in this project. Based on available process removal and cost data, the following physical/chemical treatment processes were evaluated in series with offline storage, microscreening, flocculation-sedimentation, high-rate filtration, and dissolved air flotation. A list of control technologies considered in the 1978 Needs Survey is presented in Table 2.

To control pollutants at their source, BMP's must be applied where pollutants accumulate. For combined sewers, dry-weather deposition of sewage solids in the collection system is the major source of BOD_5, TN, PO_4, and coliform bacteria. Therefore, sewer flushing, which operates in the collection system, can be expected to be more effective than street cleaning, which operates on the land surface. On the other hand, lead is a pollutant which is associated with automobile use where pollutant accumulation is predominately on the street surface. Therefore, if the removal of lead is a concern in a combined sewer watershed, street cleaning can be expected to be more effective than sewer flushing to achieve the desired objective.

Streetsweeping has received a great deal of attention during the last few years as a potential water quality control management practice. It has the major advantage of being applicable to highly developed, established urban areas. It also controls pollutants at the source and will improve the general urban aesthetics as well as water quality.

Combined sewer flushing consists of introducing a controlled volume of water over a short duration at key points in the collection system to resuspend deposited sewage solids and transmit these solids to the dry-weather treatment facility before a storm event flushes them into a receiving water. This can be done using external water from a tanker truck with gravity or pressure feed or using internal wastewater flow detained manually or automatically. Combined sewer flushing is most effective when applied to flat collection systems. Procedures are available to estimate the quantity and distribution of dry-weather deposition in sewers and for locating the optimum sewer flushing sites (Pisano and Queiroz, 1977). A recent feasibility study of combined sewer flushing indicates that manual flushing using an external pressurized source of water is most effective (Pisano, 1978).

The purpose for analyzing alternative control technologies in the 1978 Needs Survey was to establish relationships which could be used on a nationwide basis to estimate the optimal mix of source controls and treatment facilities for any desired water quality objective. The remainder of this paper describes the approach used in the 1978 Needs Survey to establish the required pollutant removal,

Table 2
Technologies for the Control of Pollution from
Combined Sewer Overflow and Urban Stormwater Runoff

Source Controls

1. Streetsweeping[a]
2. Combined sewer flushing[a]
3. Catch basin cleaning

Collection System Controls

1. Existing system management
2. Flow reduction techniques
3. Sewer separation[a]
4. Inline storage

Treatment Facilities

1. Offline storage[a]
2. Sedimentation[a]
3. Dissolved air flotation[a]
4. Screens and microscreens[a]
5. High-rate filtration[a]
6. Swirl and helical concentrators
7. Chemical additives
8. Coagulation and flocculation[a]
9. Biological treatment
10. High-gradient magnetic separation
11. Carbon adsorption
12. Disinfection[a]
13. Sludge disposal[a]

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[a]A technology with sufficient cost and performance data to be considered in the 1978 Needs Survey.

the optimal mix of control technologies, and the results as they relate to BMP's.

1978 NEEDS SURVEY APPROACH

The approach taken in the 1978 Needs Survey for Categories V and VI, utilized specific site studies to determine the interactions of an urban area, its pollutant production characteristics, and receiving water quality. These site studies were conducted in order to develop information related to receiving water impacts of CSO and urban stormwater runoff and information related to the economic optimization of facilities to control pollution from these sources. Therefore, the site studies consisted of two relatively independent phases. Phase I utilized continuous hydrologic simulation to evaluate receiving water impacts of all major pollution sources in selected urban areas and Phase II utilized production theory and marginal cost analysis to identify optimum control techniques. This information was then analyzed to develop transferable principles and relationships which were used in the estimation of national needs. Receiving water impacts were analyzed at 15 study sites and optimum control technologies were identified at 4 study sites.

Phase I--Receiving Water Impacts

The three main objectives of the receiving water impact site studies were to (1) determine if a particular urban area/receiving water system is presently exhibiting a water quality problem, (2) determine how much of the problem, if any, is due to CSO and stormwater runoff, and (3) determine the level of pollutant removal required to achieve selected water quality goals.

The water quality response of a receiving stream depends not only on the quantity and quality of stormwater runoff but also on the quantity and quality of upstream flow and point sources of pollution. These largely independent sources of pollutants and flow are made up of random or stochastic components. Thus, receiving water quality is the total effect of several random processes. Interactions among these processes can not be represented adequately when addressed from the standpoint of a single isolated rainfall/runoff event with discharge to assumed or selected receiving water flow conditions. All events should be considered as they occur in nature. In order to accomplish this objective, continuous hydrologic/water quality simulation is required.

The Continuous Stormwater Pollution Simulation System (CSPSS) was developed specifically for use in the receiving water impact portion of the site studies. A user's manual for CSPSS documents the model's theoretical basis and data requirements (Wycoff and Mara, 1979). CSPSS, a computer-based probabilistic simulation model of an urban area receiving water system, will generate long-term synthetic records of (1) rainfall, (2) runoff, (3) runoff quality, (4) upstream receiving streamflow, (5) excess sewer system infiltration, (6) dry-weather (point source) waste discharges, and (7) receiving water quality response. The simulation will account for storage and treatment of urban runoff as well as watershed BMP's. Model components utilize Monte Carlo and Markovian techniques to produce random observations of variables where possible. The model will simulate, on a long-term basis, the operation of alternative storage/treatment or watershed management schemes and will provide stochastic information on overall reduction of pollutant loadings. All runoff events are then analyzed by the receiving water response portion of the model to determine stochastic relationships between frequency and magnitude of water quality violations and the size of storage and treatment facilities or the intensity of BMP's. Once such information is known, appropriate pollutant removal requirements can be selected based on the receiving water quality desired.

Phase II--Economic Optimization

The two main objectives of economic analysis were to (1) determine relationships between the desired pollutant removal and the percentage of that removal obtained from each watershed type (i.e., combined or separate) and (2) determine relationships between the desired pollutant removal and the optimum level of effort applied by BMP's.

A procedure was developed by Heaney and Nix (1977) at the University of Florida to determine the economically optimum combination of control alternatives which can obtain any desired pollution removal established in Phase I. This optimization procedure is a graphical application of marginal cost analysis and production theory to the urban water quality problem.

Stormwater pollution controls may operate in parallel, series, or a combination of both. A parallel operation occurs when the action of one option does not impact the source of pollution controlled by a second option. Streetsweeping and sewer flushing on a combined sewer watershed are examples of parallel source control options. A serial operation is one in which the effluent from one option becomes the influent to the next. Storage of urban stormwater followed by a treatment option is an example of a serial operation.

The essential data required to perform an optimization of stormwater control alternatives are cost functions and production functions. A production function is a relationship between the level of effort expended and the pollutant removal or output obtained. The level of effort in a streetsweeping program may be measured in terms of the fraction of total streets swept daily. The level of effort in a storage/treatment system may be measured as the percent capture, of the annual pollutant load. In this case, the output of these production functions is expressed as the quantity of pollutants removed from the watershed. In addition to the production function, which relates the level of effort to pollution removal, the relationship between effort and cost must be known.

A schematic diagram of the economic optimization procedure applied to combined sewer watersheds is shown on Figure 1. As indicated,

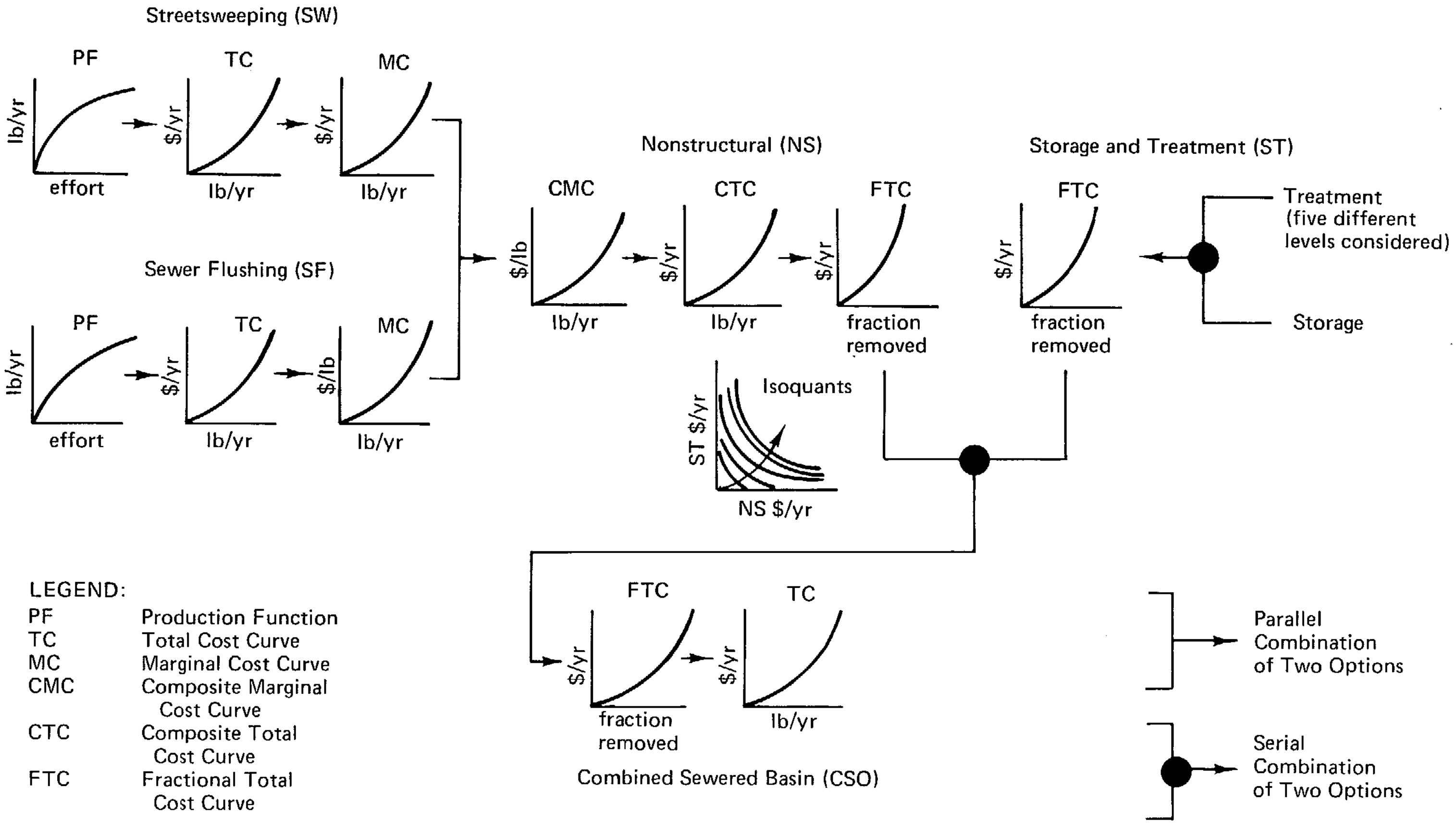

FIGURE 1. Schematic for the economic optimization of control alternatives for combined sewer watersheds.

streetsweeping and sewer flushing are combined by a parallel operation to derive a nonstructural fraction total cost curve (FTC). The nonstructural FTC is then combined by a serial operation with a storage/treatment FTC to derive the total cost curve for the entire combined sewer watershed. Figure 2 is a schematic diagram of the optimization procedure applied to control urban stormwater runoff from a separately sewered watershed. In this area, streetsweeping and storage/treatment act in series to derive a total cost curve for the entire watershed. The schematic on Figure 3 illustrates the parallel operation used to derive a total cost curve for an urban area served by both combined and separate sewer systems.

When two options are combined through a serial operation, a family of curves, termed isoquants, must be defined. The isoquants are two input/one output production functions which define combinations of the two inputs which result in an equal value of output. If lines of equal annual cost, termed isocost lines, are constructed and superimposed on the isoquants, then the point of minimum cost for each level of control can be identified. The curve which connects these minimum cost points is termed the expansion path, which defines the minimum cost possible for any desired level of pollution control.

A definition sketch of a two input/one output production process (i.e., serial operation) is presented on Figure 4. This sketch illustrates the isoquants, isocost lines, and the expansion path. The two inputs may be any two functions that operate in series. Examples include storage volume and treatment rate of a stormwater storage/treatment system or a previously optimized storage/treatment system and a streetsweeping program.

This economic optimization procedure was applied to four of the 15 study sites to determine the optimal combination of control alternatives which could achieve any desired level of BOD_5 or suspended solids (SS) removal from three basic watershed categories. These watershed categories are (1) watersheds served by combined sewers only, (2) watersheds served by separate sewers only, and (3) watersheds served by both combined and separate sewers. The four study sites selected to represent these watershed categories were (1) Castro Valley, California (separate only), (2) Bucyrus, Ohio (combined only), (3) Des Moines, Iowa (both combined and separate), and (4) Milwaukee, Wisconsin (both combined and separate). Characteristics of the economic study sites are given in Table 3.

RESULTS

The first problem to be addressed if an urban watershed is served by both combined and separate sewers is to determine how much of the desired pollutant removal should be obtained from the combined watershed and how much should be obtained from the separate watershed. Regression analysis of the BOD_5 and SS removal data developed from the economic optimization of control alternatives in Des Moines, Iowa, and Milwaukee, Wisconsin, yields the following two equations:

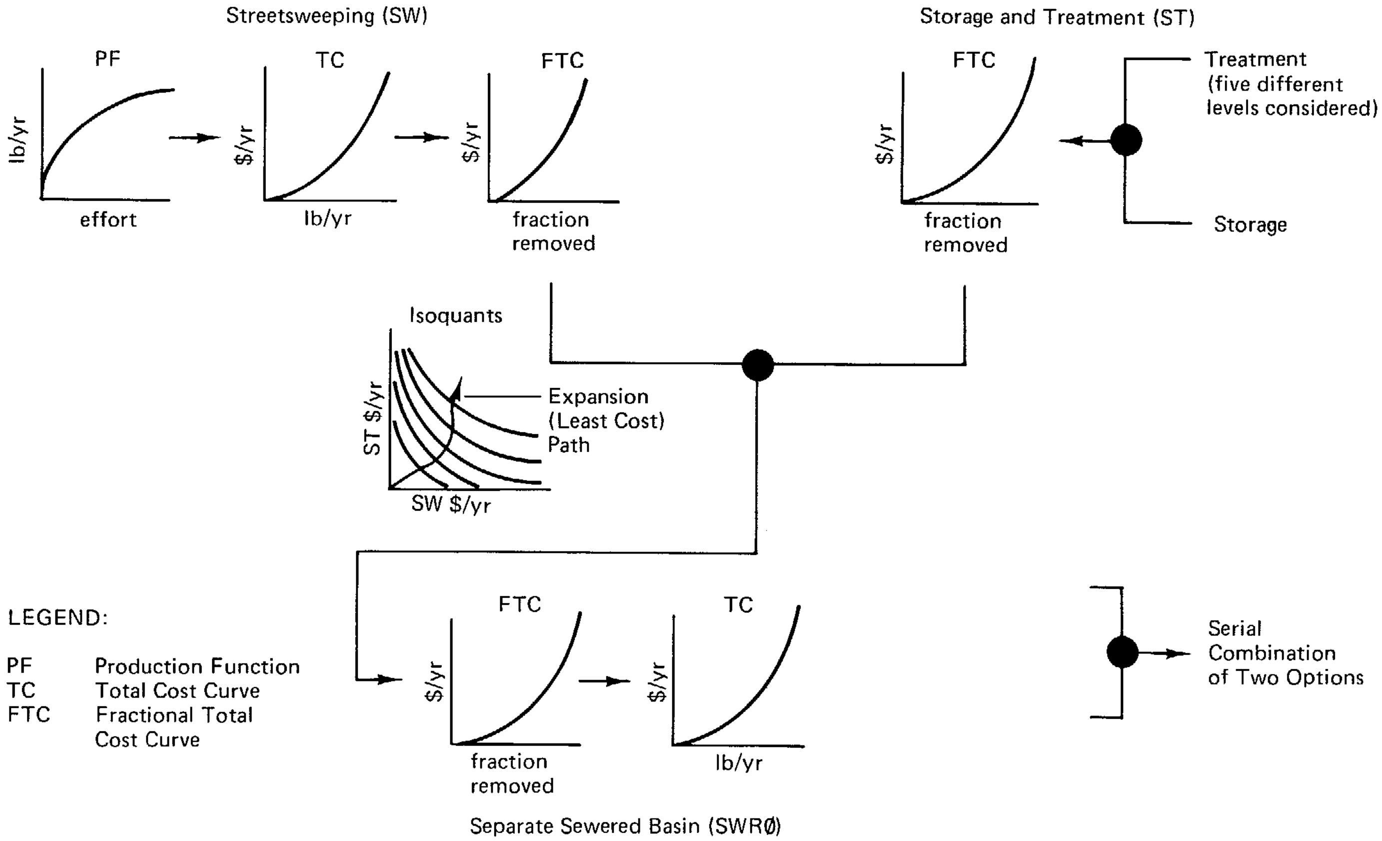

FIGURE 2. Schematic for the economic optimization of control alternatives for urban stormwater (separate sewer).

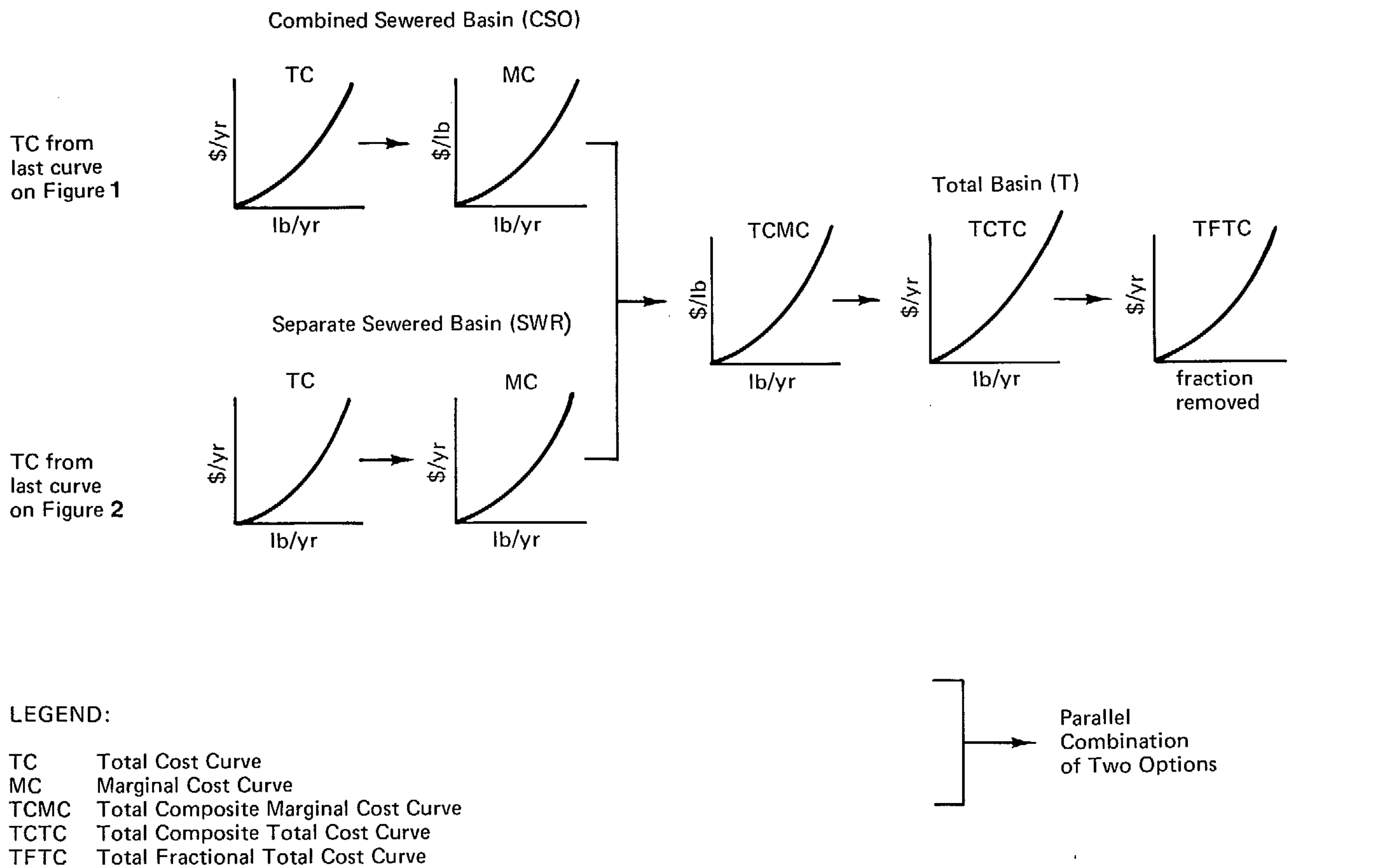

FIGURE 3. Schematic for the economic optimization of control alternatives for urban areas served by both combined and separate sewer systems.

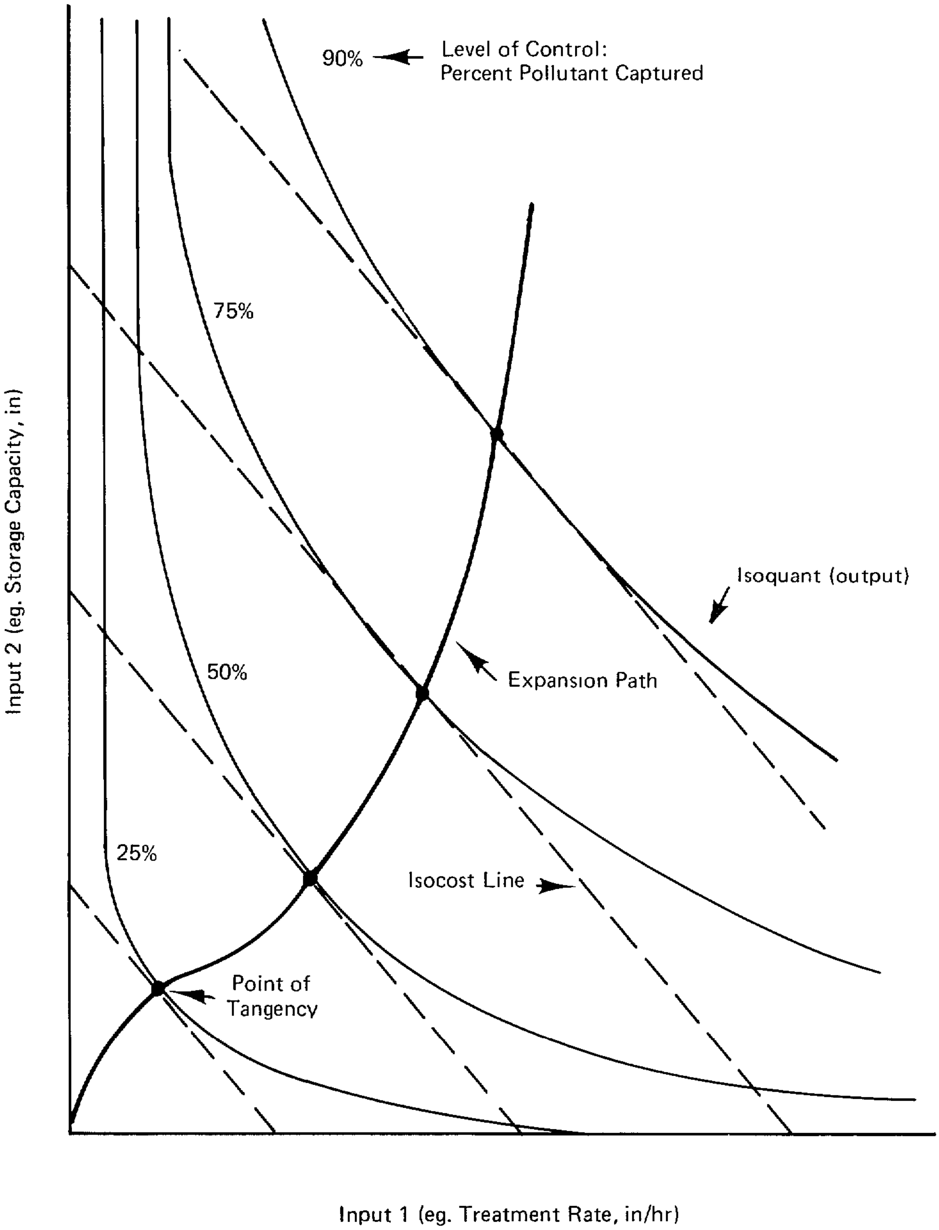

FIGURE 4. Definition sketch of two input/one output production process.

Table 3
Characteristics of the Economic Optimization Study Sites

Study Watershed	Area (acres)	Population Density (persons/acre)	Total Watershed Discharge (lb/acre-year)	
			BOD_5	SS
Castro Valley (separate)	3,850	8.00	75.6	1,238.1
Bucyrus (combined)	2,559	6.00	91.3	1,442.0
Milwaukee (combined)	5,800	27.3	319.0	851.7
Milwaukee (separate)	27,400	3.6	21.9	359.1
Des Moines (combined)	4,018	8.33	174.2	754.1
Des Moines (separate)	45,000	7.82	104.9	881.1

$$REMSWR = 0.926 * TOTREM - 2.696 * LDRAT + 111.92 * ARAT \quad (1)$$

$$REMCSO = 0.502 * TOTREM + 2.864 * LDRAT - 50.48 * ARAT \quad (2)$$

where

REMSWR = Pollutant removal obtained from SWR portion of basin, in percent of total SWR load.

REMCSO = Pollutant removal obtained from combined sewered portion of basin, in percent of total CSO load.

TOTREM = Total areawide pollutant removal required, in percent of total areawide load.

LDRAT = Load ratio defined as the unit pollutant yield from the combined portion of the watershed, in pounds per acre per year, divided by the unit pollutant yield from the separate portion of the watershed, in pounds per acre per year.

ARAT = Area ratio, defined as the combined sewer service area divided by the total area.

Equations 1 and 2 have correlation coefficients of 0.973 and 0.839, respectively, and were derived for total removal requirements in the range of 10% to 90%. The load ratio was in the range of 0.854 to 14.56 and the area ratio was in the range of 0.082 to 0.175.

Regression analysis to determine relationships between pollutant removals and the level of effort used for BMP's was not possible due to discontinuities in the data. Therefore, these data were analyzed graphically, as shown on Figures 5, 6, and 7.

Figures 5 and 6 illustrate the optimum levels of effort (x_{sw}, fraction of streets swept daily) determined for streetsweeping on separate and combined sewered watersheds, respectively. The data represent BOD_5 and SS removals from the previously identified study sites. Also shown on these figures, as a solid line, is the relationship used in the Needs Survey to select an appropriate streetsweeping level of effort given the desired pollutant removal. The discontinuity in the data occurs in the range of 30% to 40% pollutant removals and represents the point where storage/treatment systems become cost effective. Once storage/treatment facilities enter into the mix, the relative use of streetsweeping declines. However, as Figures 5 and 6 indicate, some streetsweeping is used throughout the entire range of removals. It is also apparent that streetsweeping is a more effective control and therefore used more intensively on separate sewered areas than on combined sewer areas.

Figure 7 illustrates the optimum level of effort (x_{sf}, fraction of sewers flushed daily) determined for sewer flushing on combined sewer watersheds. These data exhibit the same discontinuity and

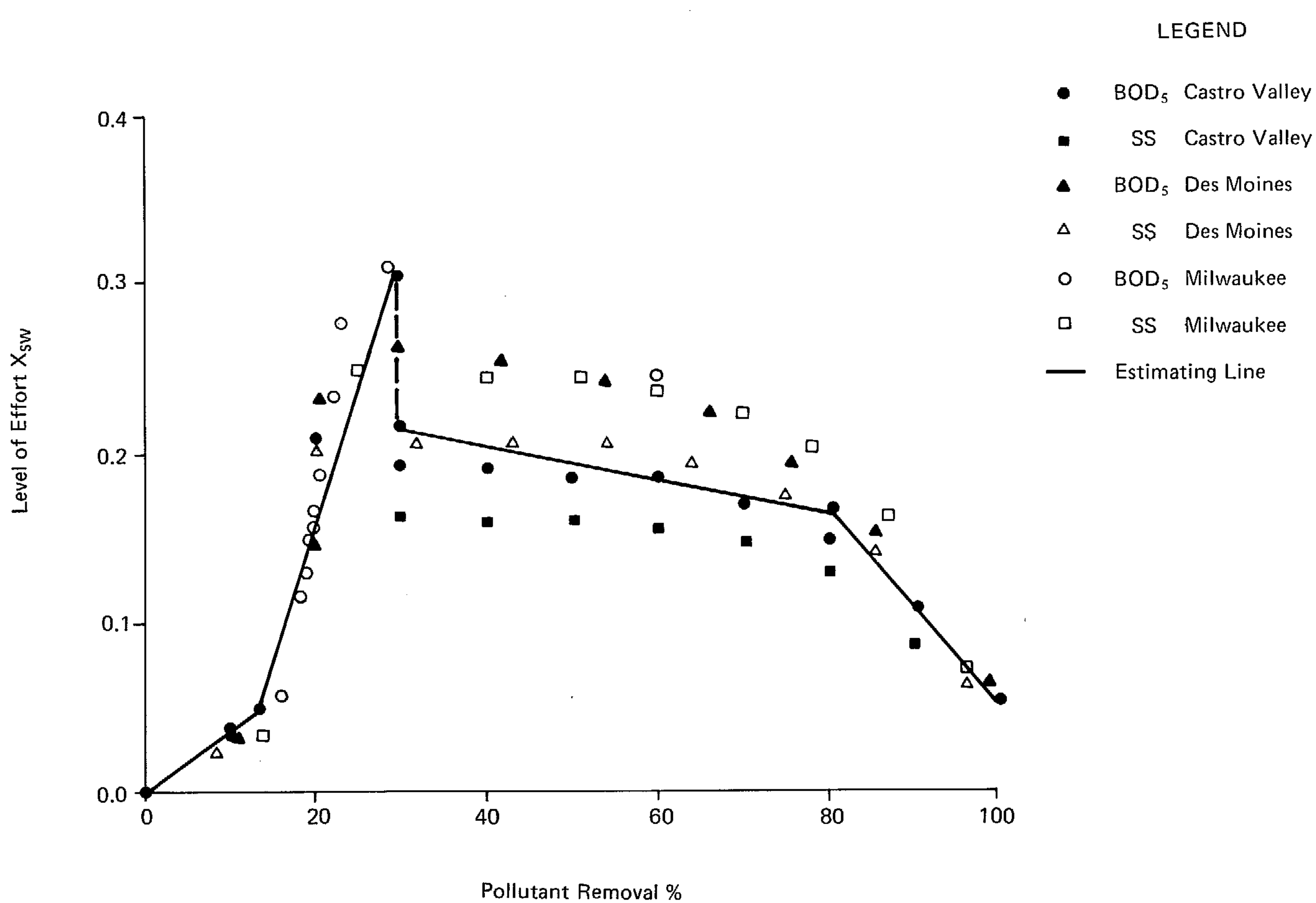

FIGURE 5. Relationship between desired pollutant removal and optimum streetsweeping level of effort for areas served by separate sewers.

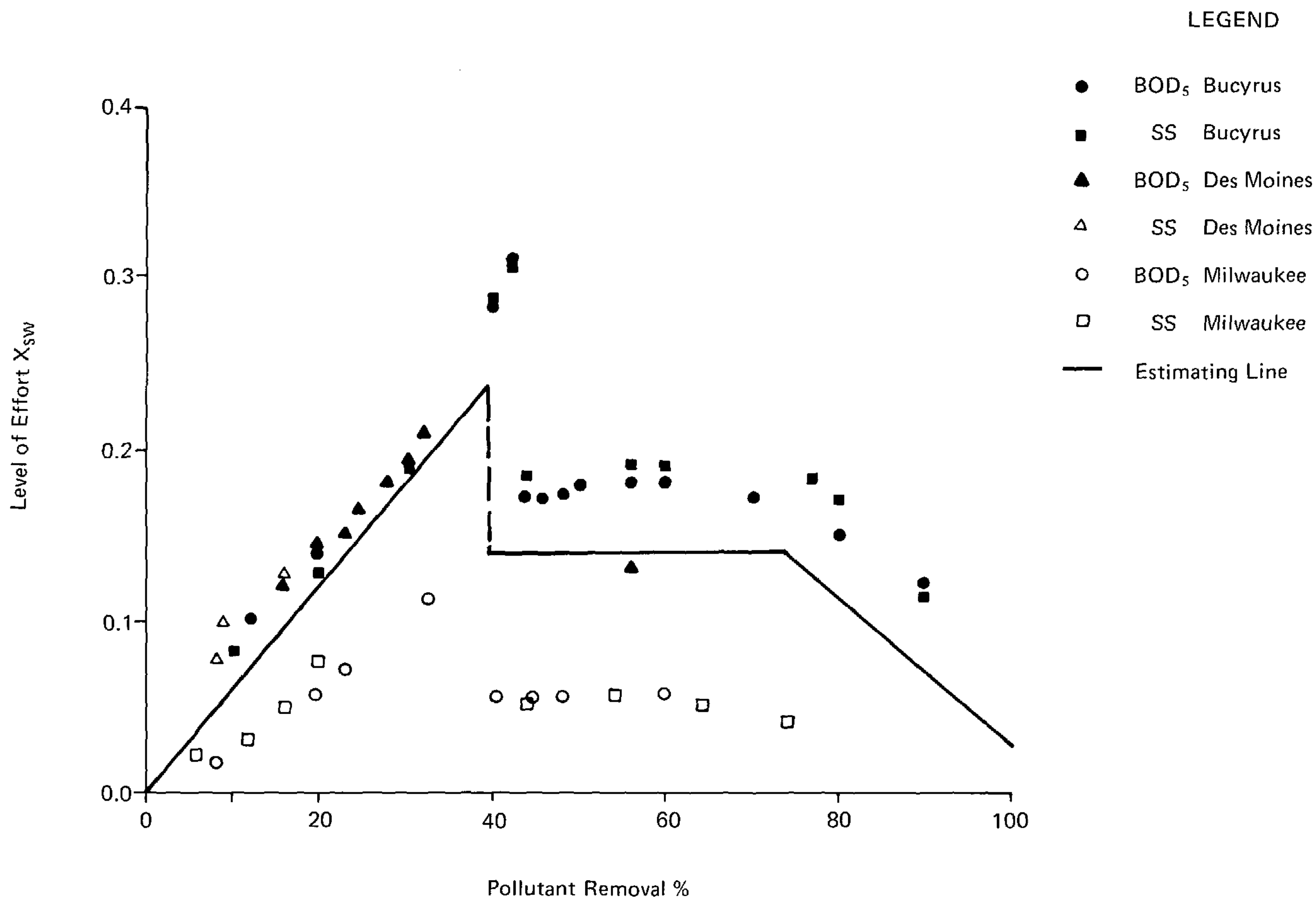

FIGURE 6. Relationship between desired pollutant removal and optimum streetsweeping level of effort for areas served by combined sewers.

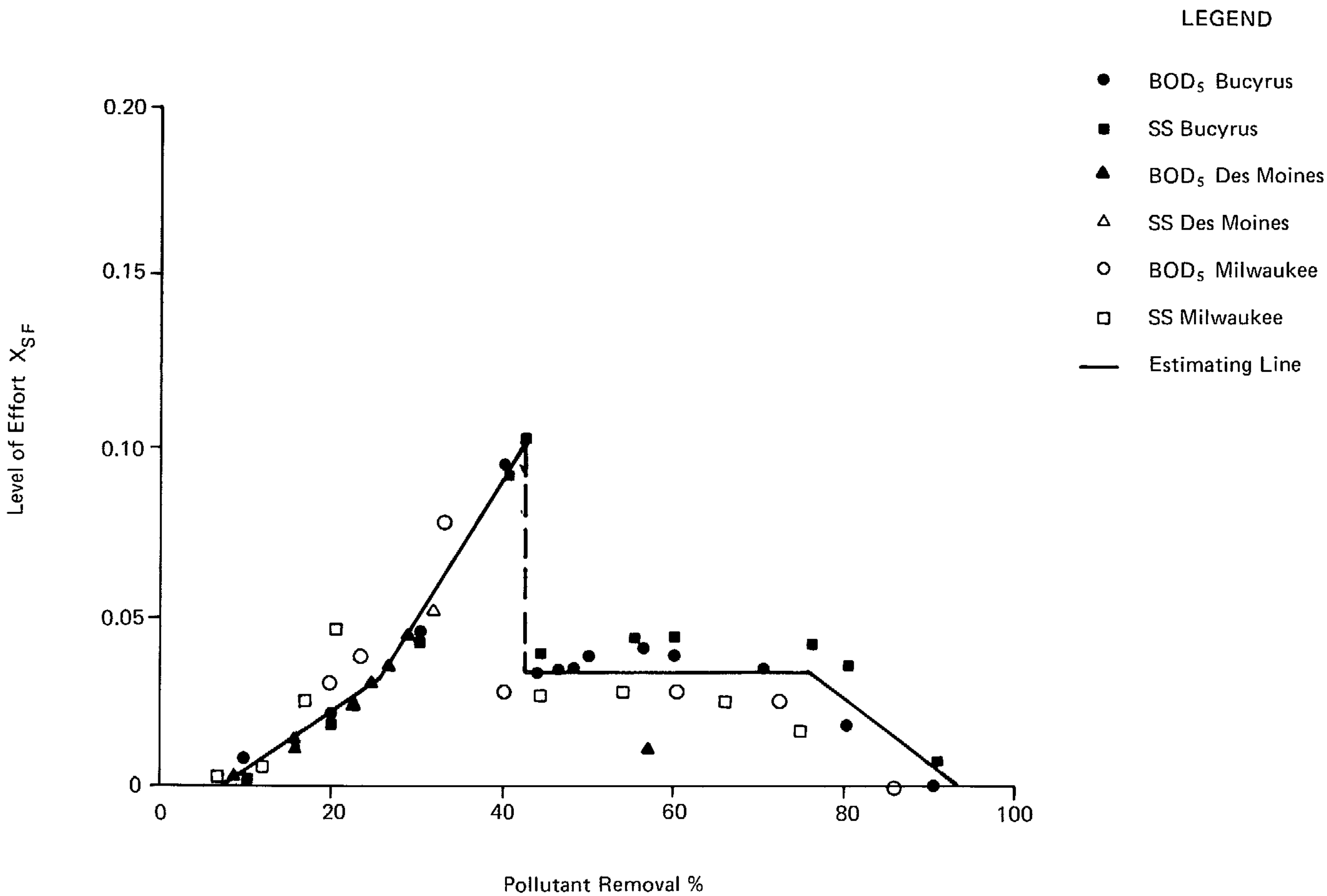

FIGURE 7. Relationship between desired pollutant removal and optimum sewer flushing level of effort for areas served by combined sewers.

overall behavior as the streetsweeping data. Maximum level of effort occurs at approximately 40% overall removal and some sewer flushing is used for nearly all desired pollutant removals.

The estimating lines shown on Figures 5, 6, and 7 were used in the 1978 Needs Survey to estimate the optimum level of effort for sewer flushing and streetsweeping once the pollutant removal required to meet the desired water objectives had been determined. Once the optimum level of effort for sewer flushing and streetsweeping were known, these levels of effort were converted to the fraction of pollutants removed by application of the appropriate production functions. If the estimated removal from BMP's was insufficient to obtain the pollutant removal required to meet the desired water quality objectives, then the remaining removal was obtained by a storage/treatment system. The removal required by storage/treatment was calculated by the following equation.

$$STR = \frac{TR - MPR}{100 - MPR} * 100 \qquad (3)$$

where

STR = Pollutant removal required from storage/treatment system, in percent of total load.

TR = Total pollutant removal desired, in percent.

MPR = Total pollutant removal obtained from management practices, in percent.

The inclusion of this economic optimization procedure in the 1978 Needs Survey indicated that it is generally more cost effective to employ a mix of control alternatives rather than a single technology. Furthermore, BMP's (i.e., streetsweeping and combined sewer flushing) were generally most useful when the overall pollutant removal requirements were low, whereas storage/treatment systems were most useful when the overall removal requirements were high.

A major attribute of including this economic optimization procedure when evaluating stormwater control alternatives is that a least-cost (i.e., optimum) mix of BMP's and storage/treatment is estimated for any desired level of pollutant removal. Therefore, the economic results can be readily adapted to site-specific cultural and social values when a decision is made to spend public monies for increasing beneficial receiving water uses.

SUMMARY AND CONCLUSIONS

The recent shift in our nation's approach for administering water pollution abatement programs mandates specific minimum treatment technologies at all point sources to obtain certain effluent characteristics. If receiving water goals cannot be met when these effluent limitations are in effect, additional point and/or nonpoint source controls may be required. Therefore, new planning approaches are required which consider the dynamic nature of nonpoint source pollution and best management practices to control them.

A two-phase approach to water quality planning was developed to conduct the 1978 EPA Needs Survey for estimating the cost of controlling combined sewer overflow (Category V) and urban stormwater runoff (Category VI) in the United States. Phase I of this approach utilized continuous hydrologic simulation of the total urban environment to estimate the required stormwater pollution removal to obtain beneficial receiving water uses. Phase II applied production theory and marginal cost analysis to identify a cost-effective combination of streetsweeping and combined sewer flushing in series with storage/treatment to obtain any desired level of stormwater pollution removal from combined or separately sewered watersheds.

Best management practices to control the accumulation of pollutants on an urban watershed can not be considered as independent pollution control alternatives but should be part of an areawide pollution control plan. These BMP's are likely to play an increasingly important role in maintaining and protecting the quality of our nation's water resources.

The economic optimization of stormwater control alternatives in the 1978 Needs Survey indicated that it is generally more cost effective to employ a mix of control alternatives rather than a single technology. Furthermore, BMP's (i.e., streetsweeping and combined sewer flushing) were generally most useful when the overall pollutant removal requirements were low, whereas storage/treatment systems were most useful when the overall removal requirements were high.

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10

ROLE OF AQUATIC BIOLOGICAL MONITORING IN DETERMINING BEST MANAGEMENT PRACTICE EFFECTIVENESS

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Introduction

The foremost challenge facing the water resources engineer of the 1980's will be the design of urban stormwater management alternatives for protecting water quality. While these "Best Management Practices" (BMP's) will surely reduce the concentration of some pollutants, uncertainty still remains concerning the source of the most serious water quality problems in urban waters.

Degradation of water quality occurs when the physical and chemical properties of a watercourse are not of adequate quality to support the designated use of that water. Recent federal legislation was passed with the specific purpose of restoring and maintaining sufficiently high water quality to support the protection and propagation of aquatic life. Consequently, evaluations of water quality must not only consider measurements of water chemistry but also the suitability of the water for protecting aquatic life.

Many urban runoff studies have produced computer forecasts of water quality improvement following the implementation of "BMP's." Often times, the interested public is confused by sophisticated modeling, and elected officials are unsure whether a 20% reduction in BOD_5 is worth the political risk that accompanies an increase in the city tax rate. More direct and easily comprehensible methods are needed to determine whether abatement measures are really required and whether they really work.

The purpose of this paper is to review the sources of pollution and the types of water quality problems that occur in urban waters. Emphasis will be placed on the functioning of aquatic biological communities in streams and rivers and how the maintenance of biological integrity is central to the proper assimilation of man's wastes. In this paper, biological monitoring is advocated as an essential tool for evaluating whether stormwater management alternatives or other pollution abatement measures really improve water quality in urban waters.

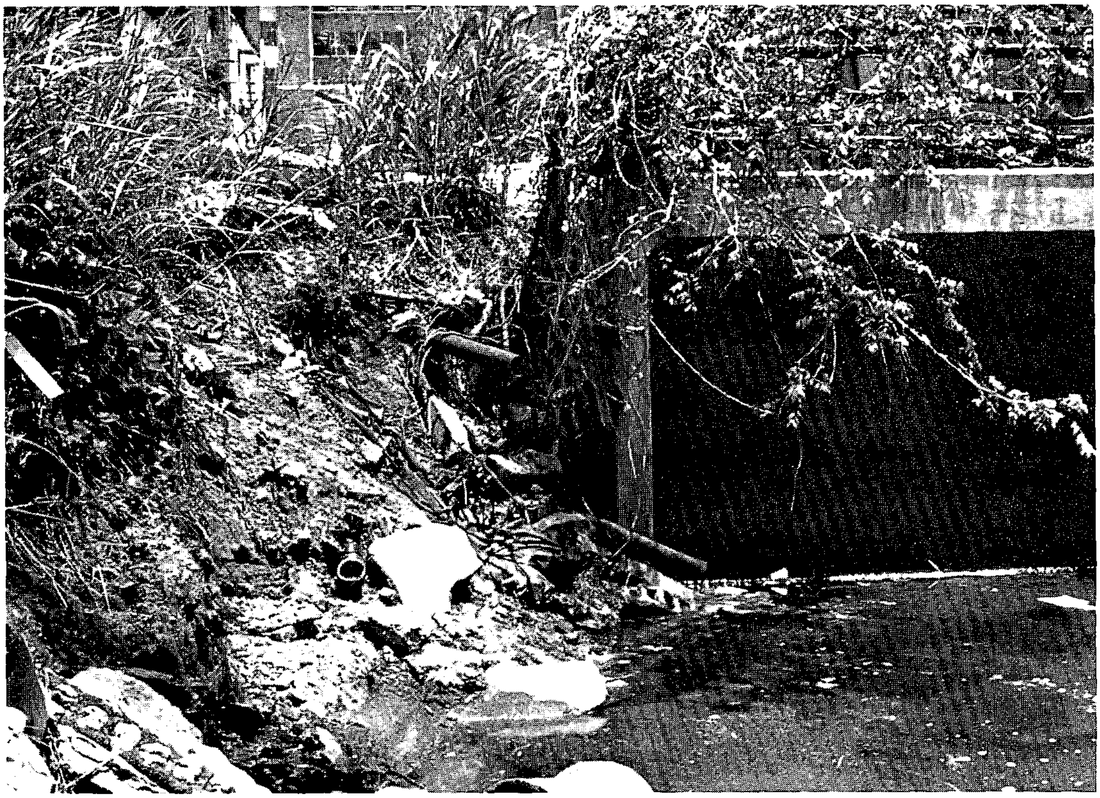
Sources of Urban Pollutants

Water quality problems are difficult to analyze in urban areas because of the complexity of pollution sources. Most sources of urban pollutants are associated either with urban washoff or with discharges of wastes. Urban washoff in itself is very complex. The contribution of atmospheric fallout and washout of air pollutants with precipitation has been documented in Houston[1] and in northern Virginia.[2] Air pollution, road surface and vehicular pollutants, and solids generated from construction projects accumulate on impervious surfaces and may be washed into streams.[3] Street litter and garbage, animal and bird wastes, or lawn and garden chemicals also contribute to the problem. However, no study has demonstrated that these pollutants associated with urban washoff cause critical biological problems in urban streams in the absence of waste discharges.

Less than fifteen years ago, municipal, industrial, and commercial wastes were routinely discharged to storm sewers and urban streams without treatment. While great strides have been made in controlling major point source discharges, manpower resources and political backing have been inadequate to find and control many smaller discharges. In some cases, these pipes are connected to water conveyances buried deep within older sections of cities. In separately sewered areas, this could prove to be a significant source of urban pollutants. Evidence presented by Duda et al.[4] has implicated these small point sources and other unrecorded waste discharges as probable causes of biological degradation in several North Carolina urban streams. Other common sources include point source discharges that do not meet their effluent limits, the illicit dumping of wastes at nights, on weekends, or during high flow as suggested by Whipple et al.,[5] or the discharging of wastes such as toxics that as yet do not have specified permit limits.

Combined sewer overflows have been identified as very serious causes of water pollution.[6] In one Michigan study, much greater loads of pollutants were associated with combined sewer overflows than with stormwater from separately-sewered areas.[7] Even separately-sewered urban areas can have water quality problems from sanitary sewers. In Baltimore, Olivieri et al.,[8] found that the old (65 year old) separately sewered system had numerous cross connections and bleeders joined to storm sewers that introduced raw sewage to urban streams during all flow regimes. Leaking or broken sanitary sewers, commonly found paralleling urban streams, may also be a major source of pollutants. Sewer System Evaluation Surveys such as the one described by Roberts[9] are finding that up to two-thirds of manholes leak and that illicit connections, storm sewer cross connections, faulty connections, and deteriorated joints and pipe may cause excessive infiltration and exfiltration. Accumulated sludge, sediment, and overloaded sewer lines may permit constant leakage of sewage through these cross-connections.

In all likelihood, the pollution problem in urban waters is caused by a combination of these sources, each with very different strategies for abatement. Should limited regulatory resources be used to address waste discharges or urban washoff? And what criteria will be used to determine when a water quality problem is severe enough to warrant the



Tha almost-familiar sight of streambank erosion, illicit discharge pipes, and litter adding to a polluted urban stream in Raleigh, North Carolina.

implementation of expensive controls? The answer to both of these questions involves the monitoring of aquatic life in streams and rivers.

Importance of Aquatic Life

The primary function of aquatic life in streams and rivers is to process energy. Aquatic biological systems process organic matter from the watershed surface and transfer energy through all the various types of biological communities as part of the ecological food chain. While leaves, twigs, and bark are important natural sources of energy, sewage and other wastes discharged by man are also broken down or eaten by successive types of aquatic life and are converted into fish for man or wildlife to eat.

All aquatic systems can cope with some level of pollutants without suffering significant biological damage. If this assimilative capacity to receive and process wastes is exceeded, adverse shifts in biological functioning will result - for example too much organic matter causing depressed Dissolved Oxygen levels that results not only in fish kills but also the death of other organisms in the food chain. It is very important to protect balanced, functioning biological communities in streams and rivers because these properly functioning communities can process or assimilate more of man's wastes than can degraded or polluted communities.[10] Consequently, the key to understanding water quality involves the knowledge of whether a normal biological community or a degraded, improperly functioning one is present.

Monitoring Water Quality

Biological monitoring directly measures the actual response of life to water quality, rather than predicting a biological response from measurements of water chemistry and the application of criteria or standards. The purpose of biological monitoring is to indicate whether a problem exists. Then it is a matter of using selected physical and chemical measurements or bioassay techniques to determine the likely causative factors.

For traditional measurements of water chemistry, grab or random sampling is not sufficient in many cases. Expensive automated samplers are necessary for taking samples during storm events. This instrumentation often breaks down, leaving incomplete records; and the equipment is expensive, making the installation of many stations cost prohibitive.

The suite of water quality parameters to be analyzed is often limited by the cost of laboratory determinations as well as the limited number of samples that can be taken by automated units. Consequently, some pollutants which may cause injury to aquatic life are never monitored. Many toxic substances are not routinely monitored because the laboratory cannot measure them, the analyses are too hard to do, or they are too expensive. Physical or chemical measurements provide little help in determining synergistic or antagonistic effects between pollutants. This is an important consideration because no pollutant acts by itself. In addition, slug doses of toxic substances are very likely to occur in urban areas - especially at night or on weekends.

Small streams often show a great variety of aquatic life, such as these spawning flounder, that were killed by a discharge of toxic wastes in a coastal stream in North Carolina.

Whether accidentally or intentionally dumped several times a year, they can totally decimate aquatic life.

Biological Monitoring

Many researchers[11,12,13] have concluded that the monitoring of benthic macroinvertebrates provides the most accurate and reproducible information on the status of water quality. These benthic macroinvertebrates are bottom dwelling animals (up to one inch in length) that live in all lakes, streams, and rivers. They are probably the most important link in the food chain because they prey on all lower forms of life, they help process organic matter (including sewage), and they provide the principal source of food for most fish. They are useful biological monitors because they are found in all aquatic habitats, they are less mobile than many other groups of aquatic organisms, such as fish, and they are large enough to be easily collected. While slugs of pollutants are often missed with chemical surveys, the macroinvertebrates, which have life cycles of more than a year, serve as natural integrators of water quality.

Benthic macroinvertebrates have been used for more than fifty years by biologists to assess the impact of water pollutants. However, it appears that the biologists did not present their information in a simple form that was useful to engineers and planners. In addition, there is a certain level of mistrust held by those who do not understand their techniques or do not want to relinquish their judgemental or decision-making authority. The complex nature of water quality problems in urban areas demands the use of biological monitoring.

Data Collection and Analysis Methods

Extensive reviews have been published that outline methods for sampling benthic macroinvertebrates in water quality studies.[11,12] The approach used in North Carolina is to sample streams quarterly for an entire year. Samples are collected by the "kick" technique. A net is positioned upright on the streambed, while an upstream area of one square meter is physically disturbed for thirty seconds. At each station a minimum of two replicate samples are collected. Samples are preserved in ethanol and returned to the laboratory, where the organisms are sorted and specimens are keyed to the lowest possible taxonomic level.

Many data analysis techniques have been outlined in the biological literature to provide quantitative interpretations of the benthic macroinvertebrate data. These techniques include diversity indices,[14] a biotic index,[13] analysis of variance,[15] and multivariate statistical methods.[16] These techniques provide powerful tools for scientists, but they often leave planners, elected officials, and the general public in a confused state.

Simple presentations of the biological damage in urban streams are more likely to be accepted by the public and elected officials. In North Carolina, simple comparisons of macroinvertebrate communities are made between upstream rural or control reaches and downstream urban reaches. When the number of different types of macroinvertebrates is reduced by more than 50 percent, it is very likely that a severe water quality problem exists.

Examples of Aquatic Biological Results

Benthic macroinvertebrates have been monitored in seven urban streams across North Carolina over the past several years. Results from two of the streams will be presented here to illustrate the biological damage that we have found in urban streams. Nasty Branch and Sweeten Creek flow through Asheville, a city of 60,000 people in western North Carolina. The entire area is separately sewered, and interceptors parallel virtually every stream in the city. Nasty Branch drains the central business district and older residential areas while Sweeten Creek drains a lower density commercial/industrial section of Asheville. A control station was established on Sweeten Creek upstream of Asheville and an urban sampling station was placed one stream mile into the city. No point source discharges were known to exist in the watersheds.

Table 1 presents a summary of the biological results. It illustrates the average number of different types of benthic macroinvertebrates found in a quarterly sample as well as the distribution of these small animals among six different categories of macroinvertebrates. The sampling demonstrated that very severe biological problems exist in the urban streams compared to an upstream rural control reach. In Sweeten Creek, the average number of different animals found in each sample was reduced 70 percent in the urban reach compared to the upstream control. In Nasty Branch, the reduction averaged 80 percent. About 35 different types of macroinvertebrates were normally found in the rural reach, while about 10 were found in the urban reach of Sweeten Creek and only 7 in Nasty Branch.

In terms of different types of macroinvertebrates found per sample, the control reach had a good mix of sensitive types of macroinvertebrates (mayflies, stoneflies, and caddisflies) that indicate good quality water. In contrast, the two urban streams are dominated by worms similar to those found below raw sewage discharges. This high percentage of worms indicates very poor water quality with excess organic wastes and periods of low dissolved oxygen. The macroinvertebrate groups that cannot live in polluted water (mayflies and caddisflies) were not just reduced in numbers, they were eliminated in the urban reaches.

Exceedingly septic conditions existed in Nasty Branch. Large numbers of the worms *Tubifex tubifex* and *Limnodrilus udekamianus*, normally found in the most polluted water below sewage discharges, dominated the benthic community. Sweeten Creek was not much better with the worms *L. hoffmeisteri* *L. udekamianus*, *I. templetoni* and the midge flies *Chironomus* and *Cricotopus* dominating the community. These sewage worms, bloodworms, and sewage flies have special types of blood or special breathing tubes that allow them to thrive in the organically polluted, low D.O. water. Fish sampling conducted by the Tennessee Valley Authority[17] found that fish life was almost nonexistent in these urban streams. While good mixes of fish were found in rural streams, only

Table 1. Summary of Biological Monitoring Results in Two Urban Streams *

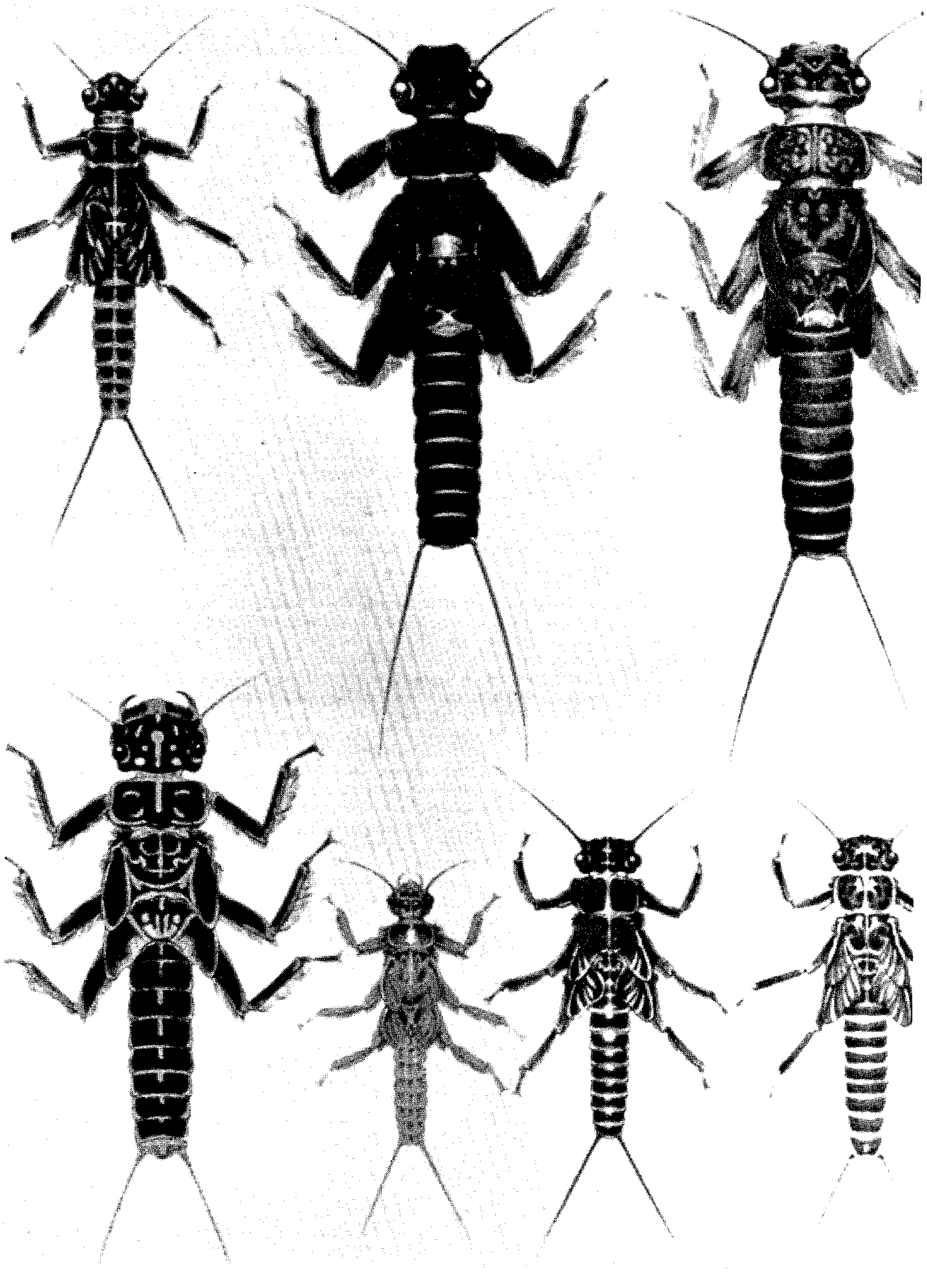
LEVEL I: SUMMARY

	Sweeten Cr. 1 (upstream control)	Sweeten Cr. 2 (in city)	Nasty Br. (in city)
Mean # of Macroinvertebrates/m^2	197	564	301
Mean # of Different Types/m^2	35.3	10.3	7.0

LEVEL 2: DISTRIBUTION OF MACROINVERTEBRATES/M^2 SAMPLE

Class of Animals	Average Number of Different Types			Average Percent Total		
	S.Cr.-1 (rural)	S.Cr.-2	N.Br.	S.Cr.-1 (rural)	S.Cr.-2	N.Br.
Mayflies	5.5	0	0.5	17%	0	0
Stoneflies	5.5	0.5	0	36%	0	0
Caddisflies	6.3	0.5	0	27%	0	0
Midges	9.8	5.5	3.0	13%	10%	1%
Worms	1.0	3.0	3.0	1%	89%	99%
Others	7.2	0.8	0.5	2%	1%	0
	35.3	10.3	7.0	100%	100%	100%

*Based on quarterly benthic macroinvertebrate samples from square meter riffle areas



When a good mix of aquatic life, such as these stoneflies, is present, water quality is being adequately protected.

one individual of one small, hardy type of fish was found in the urban section of Sweeten Creek. Other efforts have found no fish in Nasty Branch.

It was originally assumed that urban washoff was the key source of pollution since no legally permitted point source discharges were known to exist. However, detailed inspections of the watersheds implicate waste discharges as a potentially important source. Nasty Branch flows for several hundred yards under an old commercial section of Asheville and under the city motor pool. Slugs of waste and oil have been observed in the stream as it emerges from under the city. In addition, the old sewer line paralleling Nasty Branch is known to discharge raw sewage profusely. Limited water quality monitoring conducted by consultants for the area found that fecal coliform density averaged 655,000/100 ml during lowflow and 379,300/100 ml during stormflow in Nasty Branch.[18]

On the banks of Sweeten Creek, broken and leaking sanitary sewers and small pipes that do not convey stormwater have been observed. Discharges of water from the washing of trucks have been documented. Numerous gas stations and oil dispensing facilities line the stream. Property owners near the stream have commented about slugs of waste and oil slicks in the stream. Whipple and Hunter[19] have recently presented evidence that implicates such waste sources as significant contributors of petroleum hydrocarbons to urban waters in the Northeast.

The biological monitoring conducted in two Asheville urban streams found communities indicative of grossly degraded water quality. Stream surveys that were conducted in the watersheds found numerous unrecorded sources of waste discharge that may be the primary cause of the water quality problem. If this is so, should tax dollars be spent on urban stormwater "BMP's" in this built-up urban area?

Implementation of Best Management Practices

Much funding has been expended in the last decade in studying the urban runoff problem. Unfortunately, many of these studies have resulted in incomplete analyses of the cause of the water quality problem as well as its significance. The U.S. Environmental Protection Agency realized that significant gaps exist concerning the nature of pollution sources, instream behavior of pollutants, and the cost effectiveness of control measures. Consequently, it established the Nationwide Urban Runoff Program which will support 30 intensive demonstration projects across the country to investigate the cause and implement the solution for urban runoff problems.

As part of this nationwide program, a project has been funded in Winston-Salem, North Carolina. The goal of this project, as determined by the local officials, will be to evaluate whether "BMP's" for dealing with urban washoff will significantly improve water quality. Street sweeping and flushing efficiency, pollutant accumulation rates, catch-basin cleaning, the contribution of air pollution, and cost effectiveness will be investigated. Baseline measurements of water chemistry and sampling for benthic macroinvertebrates has been conducted for more than a year in the area. If water quality is really improved by these "BMP's", there should be a corresponding restoration of biological integrity to the streams. Biological monitoring will be continued in these streams to determine whether streetsweeping, flushing, and catch basin cleaning can restore aquatic communities. No effort will be made to identify sanitary sewer leaks, cross connections, or small point source discharges because the local officials have indicated that they don't want us to investigate those sources. It may be that these unrecorded discharges are a significant contributor to the water quality problem.

In order to determine how willing other local officials and members of the private sector are to assist the State in abating urban sources of water pollution, educational programs are planned for two Asheville urban watersheds and one Raleigh urban watershed. These special projects are planned for urban areas that have been found to have biological communities indicative of grossly degraded water quality. They will be designed to assess whether the abatement of small, unrecorded waste discharges-not urban washoff-will improve stream biology. Sewer System Evaluation Surveys in Asheville and Raleigh have identified cross connections and leaks in the separately-sewered areas. Municipal facilities funding (201 Grants) or voluntary action by municipalities will be relied on to rehabilitate the sewer systems paralleling the streams. All streams will be walked and steps will be initiated to eliminate illicit discharges. Gasoline stations will be encouraged to install and effectively maintain oil and grease separators. Two of the streams are lined by municipal garages, motor pools, and garbage truck washing operations. It is hoped that the educational program will result in the elimination of these pollution sources.

Discussion

Sir Francis Bacon, father of the scientific method, made many astute observations of human nature in his lifetime. One of his observations made in 1620 may be quite applicable to the study of urban water quality problems:

> The human understanding, when it has once adopted an opinion, draws all things else to support and agree with it. And though there be greater weight to be found on the other side, yet this it neglects and rejects in order that its former conclusions may remain inviolate.

Many investigators have reported that large loads of pollutants are transported from urban areas during stormflow. The assumption is often made that these pollutants were washed off impervious surfaces, and if management practices such as streetsweeping were used, water quality would be greatly improved. Many of these urban areas were quite large and inventories of pollution sources were not conducted. Consequently, much of the pollutant load might have come from the benthic resuspension and scour of unrecorded waste discharges that settled out or were biologically processed during low flow conditions. Among the readily accessible literature, only Whipple et al.,[5] Whipple and Hunter,[19] and

Duda *et al.*[4] have implicated the dumping of wastes, the discharge of petroleum hydrocarbons from service stations, and small unrecorded point source discharges as significant contributors to the urban runoff problem.

In summary, biological monitoring has a very important role to play in urban water quality studies. Aquatic communities serve as natural integrators of water quality - even at night and on weekends - while chemical surveys provide information only at the moment of sampling. It is also apparent that potential sources of waste discharge must be inventoried in any watershed that is being studied. Stormwater controls may be justified in areas with combined sewer overflows and in newly developing areas; but if state legislative appropriations for pollution control remain meager and if political considerations on the local level continue to stifle pollution control, the presence of these waste discharges would make the use of stormwater "BMP's" a waste of tax dollars.

It is unfortunate that biological monitoring in North Carolina has found that fish kills do not occur in urban streams because fish can no longer survive in them. Water quality has been degraded that much! It is also very unfortunate that only a very few projects supported by EPA's Nationwide Urban Runoff Program are planning to utilize biological monitoring. Without the use of this direct monitoring tool, publically funded urban runoff investigations may result in recommendations for more research rather than for action to restore and protect the biological integrity of our nation's waters.

Acknowledgements

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11

STRATEGICALLY LOCATING ON-SITE DETENTION DEVICES USING THE PENN STATE RUNOFF MODEL

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INTRODUCTION

Comprehensive planning for the control of stormwater runoff is becoming an increasingly significant part of overall development objectives for existing as well as developing urban communities. Successful management of stormwater runoff, and actually the overall urban water resources system, depends on the ability of urban planners and managers to predict accurately the effects that increased urban development will have on stormwater runoff. In addition to this, urban water resources managers must be able to:

- Select the most "cost-effective" and optimum storm runoff control system for a particular study area, and one that may not rely on the use of an expensive storm sewer (pipe) system.
- Accurately define the response of the selected drainage system for particular storm events.

New and innovative approaches to stormwater management are becoming more widely accepted in the engineering profession at the present time. These new approaches consider the use of many non-traditional methods of storm runoff control, such as on-site detention, as fundamental parts of community stormwater management plans.

This paper presents a brief discussion of current concepts, objectives, and methods for "cost-effective" stormwater management. In addition to this, it presents a description of a unique tool that can be used, and was in fact developed, to evaluate the current state-of-the-art techniques for watershed stormwater management. Among the most intriguing problems in stormwater management as it is being envisioned at this time is the choice of strategic locations for on-site detention devices (e.g., retention ponds) with the goal of reducing the peak discharge at a flood-prone point in the drainage basin as space-efficiently and cost-effectively as possible. One very effective way of accomplishing this is with the use of a computer simulation model. Several stormwater runoff simulation models are presently available, ranging from the very simple Corps of Engineers STORM (1) to the highly complex EPA SWMM model (2).

It is difficult, however, to find a model which combines a timing analysis of sub-basin flood flow (peak) contributions with sufficient program simplicity to allow small agencies or firms to engage in runoff modeling without a substantial programmer training effort. In response to this problem and in response to the needs of current stormwater management philosophies, the Penn State Runoff Model (3) has been developed, with the following objectives:

(1) To produce an urban runoff simulation model that will provide acceptable hydraulic accuracy while remaining at a level of sophistication compatible with minimum practice and data-collection time, and therefore minimum cost.

(2) To keep the model as simple and concise as possible, and thus convenient for use for small to medium-size communities, or for individual developments.

(3) To provide a stormwater management tool for the analysis of the timing of subarea flow contributions to peak rates at various points in a watershed. This tool is known as the Peak Flow Presentation Table, and will be described in a later section of this paper.

STATE-OF-THE-ART IN STORMWATER MANAGEMENT

Some very important changes are taking place in the field of stormwater management. Stormwater management specialists at the present time are making a serious commitment towards the development and use of more "cost-effective" methods of stormwater management. A prime example of a cost-effective technique, and one that is being used more frequently for practical storm runoff control, is on-site detention.

This new commitment to cost-effective and environmentally-sensitive stormwater management has resulted from recent research and evaluation of traditional approaches that have been used for storm runoff control. These traditional approaches to storm runoff control have typically involved seeking maximum convenience at a particular development site by rapid elimination of excess stormwater from the area. A device that has been used most frequently for eliminating excess stormwater runoff is storm sewers (i.e., pipes). Storm sewers are an excellent means of controlling storm runoff when they are properly used. This has not been the case in past practice, and storm sewers have been used to merely relieve a given area by concentrating and speeding up storm runoff. This has led to countless instances of downstream flooding and resulting environmental damage that could have been avoided by proper planning.

Much research and development work has been undertaken which has resulted in many publications being available which deal with revised and updated philosophies and concepts for stormwater management (4, 5, 6, 7). A very important set of stormwater management concepts, which reflects the most current thinking by specialists, has been presented in a publication dealing with residential stormwater management (8). These concepts are becoming widely accepted by practicing engineers and are influencing, as well as providing the basis for, stormwater management regulations in many communities. A summary of these concepts is presented below:

- The water falling on a given site should, in an ideal design solution, be absorbed or retained on-site to the extent that after development the quantity and rate of water leaving the site would not be significantly different than if the site had remained undeveloped.

- Optimum design of stormwater collection, storage and treatment facilities should strike a balance among capital costs, operation and maintenance costs, public convenience, risk of significant water-related damage, environmental protection and enhancement, and other community objectives. The optimum balance among these factors is dynamic, changing over time with changing physical conditions and value perceptions.

- A major new emphasis needs to be placed on the identification and application of "natural" engineering techniques to preserve and enhance the natural features of a site and to maximize economic-environmental benefit. "Natural" engineering techniques are those which capitalize on and are consistent with natural resources and processes. Engineering design can be used to improve the effectiveness of natural systems, rather than negate, replace, or ignore them.

- The use of on-site detention storage and "blue-green" development should be pursued, along with the increased use of storage to balance out handling or treatment of peak flows, the use of land treatment systems for handling and disposal of stormwater, and perhaps most important a recognition that temporary ponding at various points in the system, including on the individual lot, is a potential design solution rather than a problem in many situations.

- There is a balance of responsibilities and obligations for collection, storage, and treatment of stormwater to be shared by individual property owners and the community as a whole.

- Stormwater is a component of the total water resources of an area which should not be casually discarded but rather should be used to replenish that resource. Stormwater problems signal either misuse of a resource or unwise land occupancy.

- Every site or situation presents a unique array of physical resources, occupancy requirements, land use conditions, and environmental values. Variations of such factors within a community generally will require variations in design standards for optimal achievement of runoff management objectives.

- Reevaluation of the approach to basin-wide runoff management is a universal need.

The stormwater management concepts presented above identify two aspects of storm runoff control as being critical for cost-effective stormwater management; logical use of on-site detention, and comprehensive planning for stormwater management on a watershed basis.

Responsible solutions for individual developments in the absence of basin-wide plans will be more difficult to achieve particularly where current practices are based on traditional drainage concepts. For example, if current practices allow upstream development to use traditional drainage approaches that increase runoff, a development relying on new concepts might be unable to accommodate the amount of excess runoff thereby generated without additional significant costs.

The use of properly-constructed and maintained on-site detention devices are beneficial in themselves, but more importantly however, they can allow development to proceed on indvidual projects, even in the absence of a basin-wide plan. This is because the strategy for retention and attenuation of post-development peak as well as total runoff so as not to exceed pre-development values would normally be compatible with any future watershed stormwater management plan. Unfortunately this can probably only be achieved at an initially higher cost for the project. Therefore, development of basin-wide plans should be pursued where at all possible.

The Penn State Runoff Model can be used to address the two major aspects of cost-effective storm runoff control that were just discussed. The model is intended to identify optimum locations for on-site detention devices, and can perform this function on any number of subbasins which form an overall drainage basin. The major components of the Penn State Runoff Model are presented below.

THE PENN STATE RUNOFF MODEL - A BRIEF DESCRIPTION

A visible flood flow is merely the result of the combination of smaller flows from various subareas within a watershed. Subarea flow combinations are a function of the travel times of runoff from these subareas, particularly to junction points. The relative timing of peak flows from different subareas determines the magnitude of aggregate flow downstream, which in turn is directly related to the extent of flooding that is experienced.

The Penn State Runoff Model is basically an urban runoff timing analysis model. A "watershed timing analysis," as it is used here, refers to a computer study of the combinations of subarea runoff flows and of their relationship to total watershed runoff for a particular storm event. This model, developed in 1976 at the Pennsylvania State University (9), was a response to the lack of an existing runoff simulation model that could be used for the analysis of the timing of subarea flow combinations. The Penn State Runoff Model can be used to analyze the effectiveness of stormwater detention structures as a function of their location within a watershed drainage system.

The model was designed to be as concise as possible. Simpler methods of analyzing infiltration, of generating runoff hydrographs, and of routing flow through a drainage system were programmed into the model to reduce computer execution time and cut overall operational costs. The capability of analyzing subwatershed flow combinations through easily-interpreted illustrations was also an important objective in the development of this model.

GENERAL METHOD OF ANALYSIS

The Penn State Runoff Model simulates rainfall-runoff events on the basis of the following information:

(1) Rainfall inputs:

- rainfall hyetographs, which can very both temporally and spatially

(2) Watershed representation:

- physical characteristics of the watershed
- conveyance-system characteristics
- retention/detention basin storage characteristics

Based on this input, the model predicts the outcome of the storm, in the form of runoff hydrographs, which represent:

(1) Overland flow to a drainage point.

(2) Pipe flow leaving a drainage point.

(3) Surcharge flow at a drainage point.

The available documentation for the model describes the calculation techniques in detail (3); the general outline of these techniques presented here provides an understanding of the basic processes being performed.

Rainfall Analysis. To allow for the spatial as well as the temporal variation of a rainfall event, the data from several recording and nonrecording rain gauges can be applied to any subwatershed, and can be used to account for a system of rain gauges or for moving storm systems in a watershed. Weighting factors can be applied to rain-gauge data to provide a more accurate representation of the rainfall characteristics of particular subwatersheds.

Watershed Characterizations. The physical system, for model purposes, consists of the water conveyance and storage systems and the physical characteristics of the watershed itself (e.g., proportions of pervious and impervious surface areas). To facilitate calculation of actual runoff, the watershed can be divided into any desired number of subwatersheds on subareas. These subareas are numbered in downstream sequence as shown in Figure 1.

Only the main sewer (or open drainage elements) is considered, and wherever a tributary joins a main drainage stem the subarea numbering system jumps to the upper extreme of the tributary. The numbering system then proceeds in a downstream order to the next junction, where the process is repeated.

Up to three incoming drainage elements are allowed to combine at any one junction, but only one outgoing element is accepted. Sewer overflow is assumed to proceed parallel with the designated drainage element to the next subarea outlet, with a travel time equal to a specified multiple of the sewer travel time.

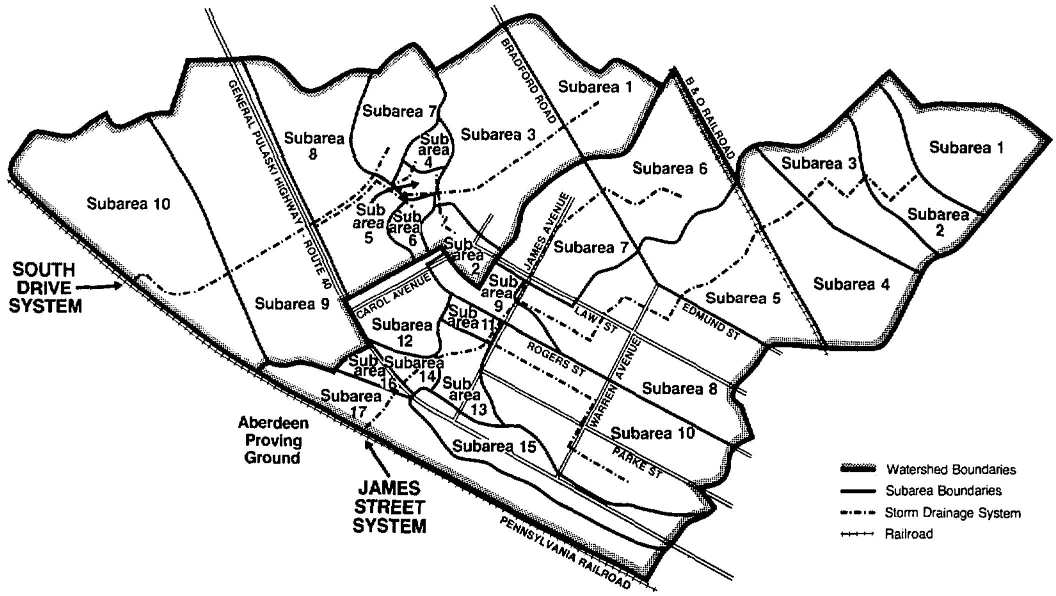

FIGURE 1 TYPICAL STORM DRAINAGE SYSTEMS SCHEMATIC

Overland Flow Calculations. Overland flow is computed by the approximate kinematic wave routing method, which makes runoff a function of accumulated water depth on a subarea. The technique estimates average depth by balancing the water budget, accounting for rainfall, inflow and outflow as well as infiltration and initial losses. The continuity equation and Manning flow equation are then solved simultaneously at each calculation time step by a simple iterative method to determine depths of runoff for an area. This depth of runoff is then converted to a runoff rate in cfs, which is the basis of the hydrograph generation used by the model.

Infiltration Calculations. Infiltration losses are estimated by a manipulation of the Soils Conservation Service (10) runoff equation into the form

$$\Delta F = \frac{S^2}{(P - IA + S)^2} \Delta P,$$

in which:

- ΔF and ΔP are infiltration and precipitation increments in inches or millimeter per unit time interval.

- S is the soil water storage capacity in the same units as F and P, as determined by the Soils Conservation Service (SCS) method.

- P is cumulative precipitation since the beginning of the storm, and
- IA is the initial abstraction, assumed to be equal to 0.1 S, in contrast to the SCS assumption that IA = 0.2 S.

This approach for infiltration calculation was prefered over the traditionally used Horton (11) equation, principally because the Horton equation depends on infiltration or permeability parameters which cannot be quantified without specific field tests, whereas the SCS parameters are obtained from data which are mapped with some degree of consistency. Various possible alternatives of the SCS-based infiltration estimating routine are described by Aron et.al.(12).

Drainage System Flow Calculations. The model routes the runoff hydrographs through the storm drainage system in a very simple, straightforward manner. The time that it takes for water to move from one drainage point to another through the storm drainage system is considered to be divided into a number of discrete steps. The specific number of steps for a given drainage system element is a function of the travel time in the element (e.g., a pipe or swale) and the time increment being used in the calculations. For each time increment, flow moves through the pipe by one step, continuing until it leaves the pipe and combines with either overland flow at a downstream subarea or pipe flow from a tributary. This process is repeated until all flow leaves the watershed.

ANALYSIS OF ON-SITE RUNOFF DETENTION DEVICES

The Penn State Runoff Model is a unique tool for strategically locating small-scale, on-site detention devices in a watershed so as to achieve cost-effective stormwater runoff control. A major emphasis by stormwater management specialists is now being focused towards on-site detention devices as the most effective means of stormwater runoff control for urbanizing areas (13). Small-scale on-site detention devices are the most efficient means of controlling runoff from frequently-occurring storm events. These events, on the order of 25-year recurrence interval and less, typically are not considered when "flood protection" programs are proposed and yet damage from these types of events can often times be very significant. The types of on-site detection devices being referred to here are:

- temporary ponding on ground surfaces
- temporary ponding on paved areas
- temponary ponding on roofs of buildings
- storage in permanent ponds having provision for variable depth
- treatment of ground surfaces to absorb and/or detain water
- routing of runoff to infiltration pits to both recharge groundwater supplies and reduce total flows to drainage systems
- collection of stormwater for supplementary water supplies.

The primary means of analyzing these types of techniques with the model is through the use of a "reservoir" analysis routine that has been built into the program. Any of the on-site detention devices that have been mentioned above can be represented as a "reservoir,"i.e., their function is to detain and/or retain runoff in a certain area of given volume and they release flow from that area at a given rate. Sound engineering judgment must be used in representing a particular on-site detention device by the characteristics of a reservoir.

Two reservoir types can be considered in the model. The first (Type 1) is used to accommodate the overland flow contribution from the subwatershed on which it is located, plus the surcharge, or overflow, from upstream areas (a typical on-site detention device). The combined hydrograph from these two sources is then attentuated by the reservoir routine and returned to the inlet point at the lower end of the subwatershed, where it combines with the pipe flow from upstream areas to become total subwatershed outflow.

The second type reservoir (Type 2) is located at the subwatershed outlet and can allow the entire outflow to be diverted and attentuated, whether this outflow consists of pipe or surcharge flow. The type of reservoir, naturally, is much more effective than the previous type for diverting a large flood volume. However, unless this reservoir is of a substantial size, it may easily fill up with the first flush, as illustrated in Figure 2, and overflow by the time the flood peak arrives.

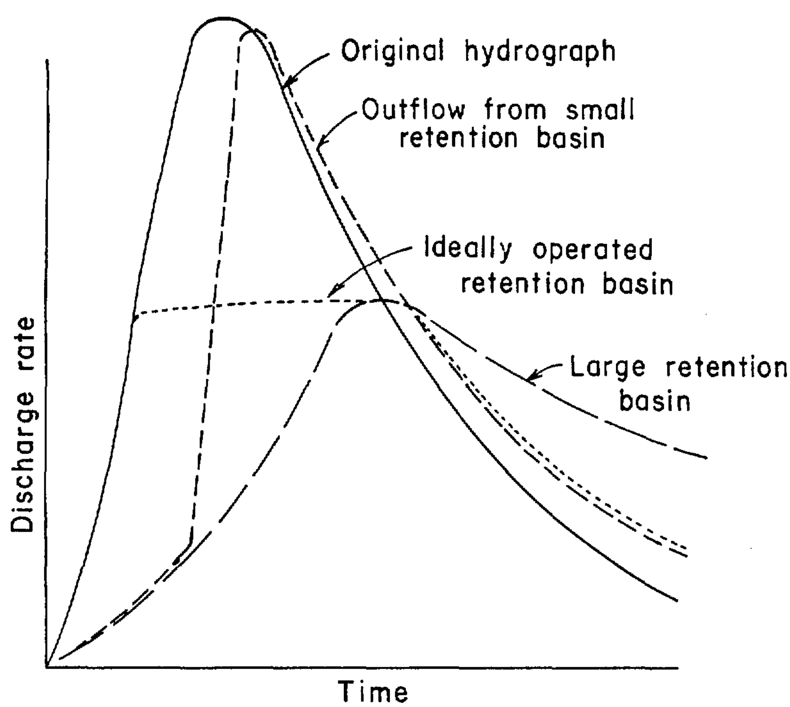

FIGURE 2 RESERVOIR EFFECTS ON FLOOD HYDROGRAPH

To remedy this situation a variable (JBYP) can be introduced for each watershed in which a Type 2 reservoir is being analyzed, representing the percentage of outflow pipe capacity which will bypass the reservoir. Specifying JBYP = 60, for example, allows the outflow to proceed down the storm sewer until it reaches 60% of the sewer capacity, at which time the excess will begin to spill over into the reservoir. It was found that this bypass option is highly effective in cutting the reservoir size needed for a particular desired reduction in flood peak. However, this early flush bypass may be a counter-productive policy if treatment of the highly polluted and sediment-laden flush is part of the storm sewer operation policy.

The reservoir routine can be performed for a maximum of ten reservoirs in a given run. The input data required for the reservoir routine are corresponding storage (acre-feet) and outflow (cubic feet per second) values.

ANALYSIS OF SUBAREA PEAK FLOW TIMING

An important feature in the model is the Peak Flow Presentation Table. Its function is mainly to display the individual runoff contributions from upstream subareas to a chosen flood-prone location, including the timing of such peak flow contributions. The flow rates presented in a Peak Flow Presentation Table reflect the travel time in the drainage system from an individual subwatershed to the particular point of interest downstream. This point of interest can be a point of observed stormwater flooding, or it can be any point in the drainage system where the analysis of the effects of stormwater runoff is desired. Presentation and review of this table enables the model user to see which subwatersheds are contributing the most critical flows to a downstream point, and to spot particularly harmful combinations of subwatershed flow rates. Thus it points the planner to those locations chiefly responsible for the flood problem, and allows the strategic placement of retention basins.

Figure 3 contains a sample Peak Flow Presentation Table taken from model output for the anaysis of a ten-subwatershed system, along with a description of the major components of the Table.

MODEL INPUT AND OUTPUT

The major operations performed by the Penn State Runoff Model are the generation of hydrographs and the routing of these hydrographs through the storm drainage system. Therefore, the general input data requirements are those which define the rainfall event, the area from which runoff will take place, and the storm drainage system that will transport the flow through the watershed. The specific input data required for the computer program includes subbasin areas (acres), approximate land slopes and overland flow widths, percentages of impervious area, roughness coefficients, and SCS curve numbers for the pervious areas, as well as pipe conveyance capacities and travel times between points in the storm drainage system. Aside from these physical data, rainfall increments per chosen time interval must be entered for at least one and at most twelve rain gages.

```
*****************************************
***** PEAK FLOW PRESENTATION TABLE *****
*****************************************
```

*** SUBWATERSHED CONTRIBUTIONS TO PEAK FLOWS AT INLET NO. $\boxed{10}$ ***

SUBWATERSHED — FLOWS ARRIVINC AT SPECIFIED TIME:

ID	TT	18	24	30	36	42	48	54	60	66	72	78	84	90	96
1	19.2	0.0	0.1	0.5	1.7	4.9	21.7	19.2	18.0	16.1	15.4	15.0	11.9	9.6	8.0
2	16.5	0.0	0.1	0.4	1.1	2.9	12.2	8.8	7.9	6.7	6.2	5.8	4.1	2.9	2.2
3	17.2	0.0	0.1	1.1	3.9	11.5	47.7	41.8	37.7	32.8	30.6	29.7	23.5	19.0	15.
4	15.6	0.0	0.0	0.3	0.3	1.7	11.5	6.5	5.0	3.6	3.1	2.9	1.4	0.8	0.5
5	12.6	0.1	0.8	2.1	4.5	18.9	11.0	9.3	7.1	6.4	5.9	3.3	2.1	1.4	1.0
6	13.5	0.1	0.4	1.2	2.9	11.5	7.9	6.9	5.7	5.3	5.0	3.4	2.5	1.9	1.
7	12.1	0.1	0.5	1.8	5.0	19.6	15.4	13.5	11.5	10.8	10.3	7.8	6.0	4.8	4.0
8	11.6	0.0	0.4	1.4	4.3	17.3	17.4	16.6	14.9	14.0	13.5	10.8	8.7	7.1	5.8
9	7.3	0.2	0.6	2.1	10.8	13.3	15.0	15.4	16.0	16.6	15.1	13.7	12.5	11.5	10.
10	0.0	0.6	2.4	15.2	18.8	21.4	22.2	23.3	24.4	22.3	20.2	18.5	17.1	15.8	14.6
TOTAL OUTFLOW		0.9	5.9	27.8	56.3	133.6	176.2	161.8	147.2	134.6	125.5	109.6	87.0	73.1	62.

*****DESCRIPTION OF PEAK FLOW PRESENTATION TABLE*****

THE ABOVE TABLE LISTS THE FLOWRATES FROM EACH INDIVIDUAL SUBWATERSHED AS IT COMBINES WITH THE FLOW RATES FROM OTHER SUBWATERSHEDS TO FORM THE TOTAL FLOW RATE AT THE POINT OF INTEREST. THE FLOWRATES FOR INDIVIDUAL SUBWATERSHEDS ARE TRANSLATED IN TIME BY THE AMOUNT OF TIME THAT THE FLOW TAKES TO TRAVEL FROM THE DRAINAGE INLET OF THE SUBWATERSHED TO THE POINT OF INTEREST FOR THE PEAK FLOW PRESENTATION TABLE. THE SPECIFIED TIME INTERVALS REFER TO THE POINT OF INTEREST, AND THE FLOWRATES IN THE ROW MARKED *TOTAL* REFER TO THE PIPE FLOW RATES ACTUALLY OBSERVED AT THE POINT OF INTEREST.

SURCHARGE, OR OVERFLOW, HAS OCCURRED AT INLETS NO.
1 3 4 5 10

MAJOR COMPONENTS OF "PEAK FLOW PRESENTATION" TABLE:

1. Subwatershed Identification Numbers.
2. Travel Time for a Particular Subarea - amount of time that it takes for flow to travel from the particular subarea to the point of interest.
3. Point of Interest - point in the storm drainage system for which the analysis and table are being presented.
4. Time Steps in Minutes - time periods for the hydrograph at point of interest.
5. Calculated Total Flows for the Point of Interest - Includes overland flow (Total Outflow) for the subarea at the point of interest, plus upstream flow contributions.
6. Calculated flow for the particular subarea (ID), for the time when this flow reaches the point of interest.
7. Indication of those subareas where surcharging has occurred.

FIGURE 3 PEAK FLOW PRESENTATION TABLE

The program output consists of all flow rates as well as cumulative rainfall and storages which are printed for all subareas requested. Hydrograph plots can also be requested.

PROGRAM SIZE AND REQUIREMENTS

The Penn State Runoff Model contains about 760 Fortran IV statements, and requires roughly 200 K bytes of computer memory. No off-line or scratch files are required. The model requires considerably less computer time than the HEC-1/HEC-2 package, the EPA Stormwater Management Model, and in fact most other widely-used stormwater runoff simulation programs.

APPLICATIONS AND CASE STUDY USE

The Penn State Runoff Model is beginning to be applied and used by consulting engineering firms for various practical stormwater management and planning studies. Original verification of the computational routines in the model was performed using the data for the Winohocking Watershed in Philadelphia, and the Boneyard Creek Watershed in Illinois (9). A complete description of the development of the model, including its application and verification is given in a Pennsylvania State University research publication (9). A detailed description of a case study application has been prepared for several national stormwater management conferences (14, 15). Other locations where the model has been applied include York,Pennsylvania, Bergen County, New Jersey, and Tucson, Arizona.

SUMMARY

The Penn State Runoff Model is an effective tool for analyzing cost-effective stormwater management systems for developed and developing areas. The model was developed in response to a need for such a tool for use in evaluating the state-of-the-art techniques for stormwater runoff control. A thorough verification of the program was performed as part of its development, and it has been used for several practical stormwater management applications. This paper presents an overall description of the capabilities of the Penn State Runoff Model, and highlights its applicability for state-of-the-art stormwater management.

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12

PLANNING FOR RIPARIAN ENVIRONMENTAL QUALITY OPTIONS IN A SMALL WATERSHED IN NEW JERSEY

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Abstract. Hydrologic, environmental and fiscal analyses of proposed Master Plan Development in the Pond Run watershed in Hamilton Township, Mercer County, New Jersey were conducted to develop measures to mitigate the plan's potential impacts. Two major measures--stream corridor protection and strict stormwater management--were selected to minimize additional flood hazards and maximize environmental quality. Strategies for implementing these recommendations were prepared and presented to Township officials.

I. INTRODUCTION

Background

Pond Run, a major tributary to the Assunpink Creek, drains approximately 9 square miles of gently sloping terrain in Hamilton Township, Mercer County, New Jersey (Figure 1). The stream system is composed of two major components--Pond Run and the North Branch of Pond Run--and several small tributaries. Existing land development in the northern and western portion of the watershed adjacent to the City of Trenton is primarily high and medium density residential. Land use in the middle and upper sections of the watershed consist of agricultural land, open space, and low and medium density residential (Figure 2).

Flooding is a major problem in the Pond Run watershed. Floods in August 1971 and July 1975 resulted in extensive inundation. Damage was primarily due to the extensive amount of residential development located on the flood plain. In addition, recent upstream residential and commercial development has resulted in an increase in flood magnitudes and frequency.

The Pond Run watershed is projected to undergo significant development in the near future. The Township plans to extend a wastewater interceptor sewer up the watershed, which will allow development to occur in accordance with the recently completed Master Plan. Development pressure is intense in this section of New Jersey, and once wastewater systems are provided, it is expected that major proposals for residential and commercial developments will proceed quickly. Up until this time, the soil limitations for adequate septic field system operation have prohibited extensive development in the middle and upper portions of the watershed.

The Master Plan indicates that population within the watershed will increase by over 67% at ultimate development levels. The only public open space shown in the Master Plan is a 254-acre park surrounding Hamilton Lake on the mainstem of Pond Run (Figure 3). Unless carefully planned, the anticipated increase in development has the potential to exacerbate flooding conditions, degrade water quality and radically change the character of the watershed.

Study Objectives

The overall objective of this study was to develop a strategy which Hamilton Township could follow to both accommodate anticipated growth and mitigate development-related problems. The study documented the impacts which could be expected from development as proposed in the Master Plan. Impacts included stormwater runoff and flooding, environmental considerations and the costs for community services and facilities. Measures were recommended for reducing unacceptable impacts and a plan was proposed to implement recommended mitigative measures.

II. METHODOLOGY

Hydrology Analysis

The Soil Conservation Service's TR-20 computer model was used to determine the rainfall-runoff volume and resulting peak flow rates for the Pond Run watershed. This method employs the use of a

Figure 1
Pond Run watershed

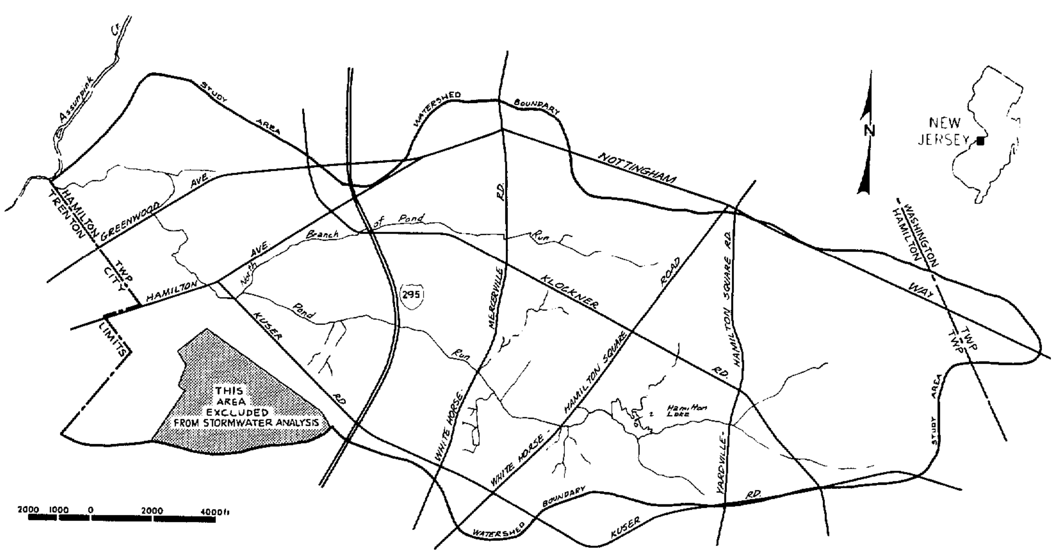


Figure 2
Existing Land Use

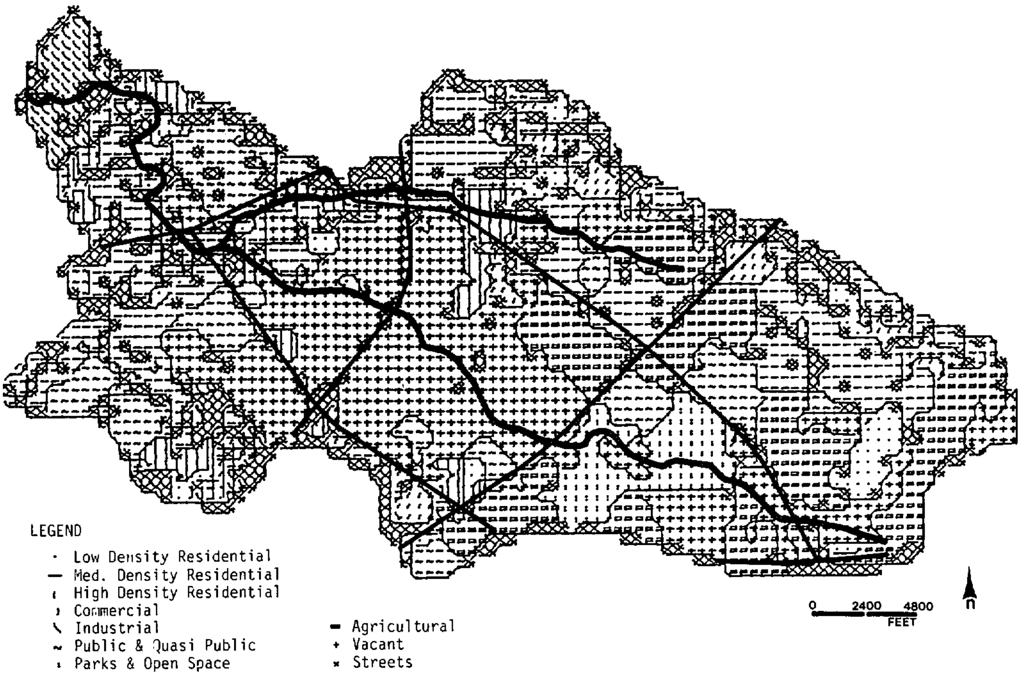
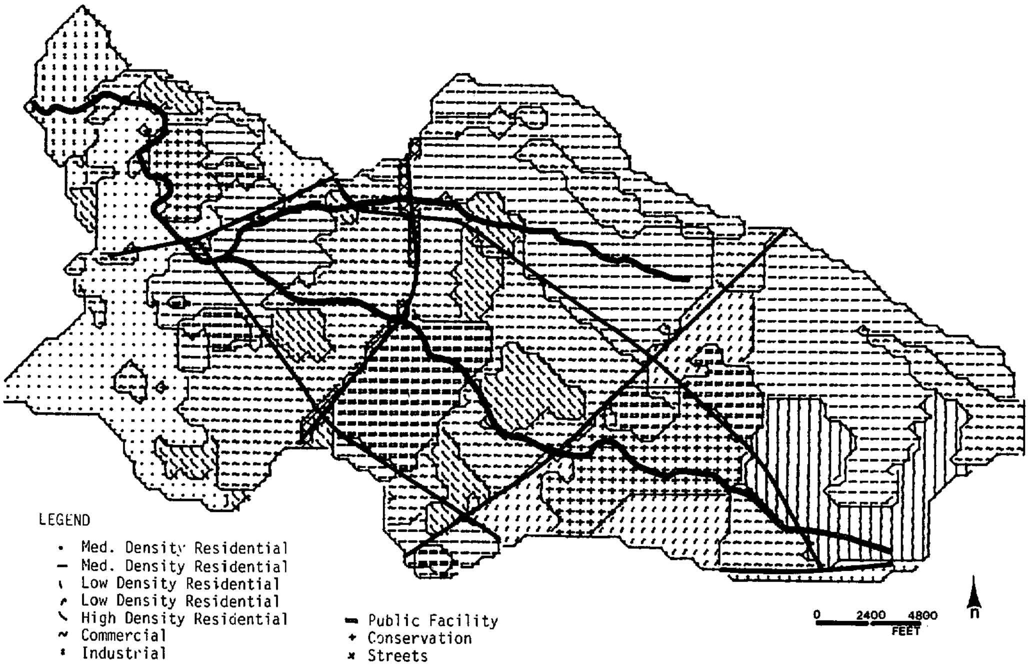


Figure 3
Master Plan Development



computer program which, when provided certain watershed data, acts as a hydrologic model of the watershed. The model can be used to evaluate various flow conditions, present and future flow rates, and alternative flood reduction schemes.

Field-measured stream channel and culvert information and data describing watershed characteristics, including topography, soil types, stream slopes, and land use, were used to construct the Pond Run Hydrologic computer model. The IMGRID computer model, a grid cell computer mapping program, was used to assist in the development of some of the data used directly in the TR-20 model. These data were used to define and quantify those watershed characteristics that affect the quantity and distribution of runoff, and subsequently, the peak flow rate.

Information published by the National Weather Service on flooding from the 10- and 100-year, 24-hour duration storms for Mercer County, New Jersey, were used for watershed flood and stormwater management analysis. Evaluations of the 10-year and 100-year storms, which have a ten percent and one percent chance, respectively, of occurring in any given year, were made in order to analyze a broad range of flood events. Existing and potential future watershed land use and stream channel characteristics were used for flood evaluation. Future land use characteristics were obtained from the Hamilton Township Master Plan.

It was necessary to modify three of the standard procedures recommended by the Soil Conservation Service for the TR-20 model in order to properly represent the watershed's rainfall and runoff characteristics. The decision to make the modifications was made with the concurrence of the SCS's New Jersey State Engineering Office in Somerset, New Jersey. The changes involved three model components--the dimension hydrograph, the reach routing equation, and the rainfall distribution.

The Pond Run watershed was sub-divided into 20 smaller sub-basins for the purposes of the analysis. Sub-dividing the watershed permitted a more detailed analysis, which allowed the analyst to locate areas that contribute significantly to peak runoff and to more carefully evaluate potential stormwater and flood controls.

Environmental Assessment

A grid cell computer mapping program was used to inventory and assess the environmental features of the watershed. A two-acre grid cell was used. Existing natural resource maps were modified by field survey information, digitized and added to the computerized data base. Changes in land use and impacts to the natural environment were determined by overlaying the maps of the individual environmental parameters with the map of the Master Plan development level. The use of computerized graphics facilitated quantitative assessment of land use changes and overlaying or compositing of environmental factors to establish land suitability for development.

Analysis of water quality conditions was based on secondary data sources. Loadings of suspended solids to the stream and the eutrophication potential of Hamilton Lake were also assessed. Changes in suspended solids loadings from existing to Master Plan development levels were calculated using the acres in developed area, agricultural land, forest and open space with the appropriate runoff loading rates of total suspended solids developed by the U.S. Environmental Protection Agency (1977) in the Areawide Assessment Procedures Manual Vol. 1, (208 NPS Manual). The Hamilton Lake eutrophication level was established using the Vollenweider critical phosphate potential for a lake of that size and comparing it to the phosphate concentrations anticipated at the Master Plan level of development.

Fiscal/Industrial Analysis

A computer model was used to evaluate the costs of services and revenue return for the Pond Run watershed. The evaluation was conducted using existing population levels, anticipated levels at Master Plan development and levels modified by land use mitigative measures. A review of existing Township ordinances was made to determine the implementation feasibility of the recommended mitigative measures.

III. STUDY RESULTS

General

This section sets forth a summary of existing conditions and a discussion of impacts caused by development proposed in the Township's Master Plan. To present worst case conditions, it was assumed that no mitigative measures would be used.

Summary of Existing Conditions

The Pond Run watershed has a population of approximately 35,000; 42% of the watershed is in residential use and streets, and 15% is in commercial, industrial, public and quasi-public holdings. The remaining 43% is in open space. Figure 2 shows the existing land use pattern. The most developed areas are found in the lower third of the watershed and along the North Branch of Pond Run. The majority of the existing open space is found along the main branch of Pond Run.

Flooding is a major problem in the Pond Run watershed. Major floods of August 1971 and July 1975 resulted in excessive inundation and damage. The great number of homes and other buildings located in the flood plain has been the principal reason why flood damage has been so extensive. Another reason is increased stormwater runoff due to urbanization.

In response to the flooding problem, the Soil Conservation Service (SCS), working together with the Mercer County Board of Freeholders and Township officials, designed and constructed a flood retarding dam in the watershed (Hamilton Lake) and has partially completed a channelization project. The dam and channel projects were designed to protect the lower reaches of Pond Run from flooding during all storms more frequent than the flood with one percent chance of occurring in any given year (the 100-year flood). These improvements, while reducing the flood problem in a large portion of the watershed, do not eliminate the potential for flooding in the densely developed lower reaches, nor do they provide protection for those homes located on the flood plain of the North Branch or areas upstream from Hamilton Lake. (See Figure 4).

Water quality in Pond Run is moderately good. Major problems are sedimentation and nutrient levels. The changing land uses and development adjacent to the creek appear to have the greatest negative impact. Suburban development, road construction, and commercial expansion have resulted in heavy erosion and runoff, causing a heavy load of sediment. In addition, many minor encroachments and dump sites occur along the stream in residential and commercial areas. The upper reaches of Pond Run appear to be in relatively good condition, supporting an abundance of small game and plant life. The middle section of the stream is characterized by high sediment loading, a heavy growth of aquatic vegetation, and stagnant sediment loading, a heavy growth of aquatic vegetation, and stagnant water. The lower section of Pond Run is channelized and contains several industrial discharges. Thermal pollution, heavy urban runoff, garbage dumping, channelization, and point source discharges have degraded this lower section. Using a simplified model for phosphorus loadings, Hamilton Lake was shown to have a high potential for eutrophication.

Although there are few "environmentally sensitive areas" in the Pond Run Watershed, the environmental character of the area will change significantly with future development. Currently, 43% of the watershed is in open space, 19% is in forest cover, and 14% is cultivated. Significant portions of the watershed are located over the outcrop area of the Magothy-Raritan Aquifer, a regional water supply source. Because of soil characteristics, 16% of the watershed is considered a prime recharge area for this aquifer.

Summary of Significant Impacts due to Master Plan Development

Impacts of land use changes proposed in the Hamilton Township Master Plan were analyzed for fiscal, stormwater, and environmental elements of the watershed. To present worst conditions, it was assumed that existing trends and construction practices would continue and no mitigative measures would be used. Table 1 summarizes the anticipated impacts.

TABLE 1
Impact Summary Matrix

Element Evaluated	Importance	Impact (at Master Plan Level of Development)
Land Use/Population	• As population grows, so does number of households and land development activty • Density is measured for entire watershed. Actual density will be higher in residential areas	• Density presently 6 persons/acre, changes to 10
Land Use: Open Space	• Contributes to aesthetic quality of watershed • Adds wildlife habitat diversity • Recreational resource	• Loss of 2,202 acres (86%) • Major, long-term, permanent
Land Use: Agricultural Land	• Provides local produce • Adds wildlife habitat diversity • Preserves open space	• Loss of 806 acres (100%) • Major, long-term, permanent
Fiscal	• Ample fiscal resources must be available to provide the necessary services to citizens	• $6.6-million surplus revenue when fully developed
Flooding	• Hazardous to life and health • Causes great loss of property	• Major flooding problems will occur from Assunpink Creek to Kuser Road, in the vicinity of Barbara and Lorraine Drives, and along the North Branch downstream of Klockner Boulevard
Vegetation	• Maintain plant and animal diversity • Aesthetically pleasing • Slow runoff and erosion	• Forests: Loss of 1,022 acres (92%) Shrub: Loss of 92 acres (98%) Fields: Loss of 820 acres (87%) • Major, long-term, permanent
Water Quality	• Public health factor • Maintain aquatic and terrestrial ecosystems • Aesthetic value	• Sedimentation in Pond Run will alter stream morphology and biotic community • Base flow of Pond Run will be reduced • Runoff from development will increase eutrophication potential of Hamilton Lake and nutrient levels of all stream segments • Sedimentation will reduce storage capacity of Hamilton Lake

Population/Land Use: Significant changes in population density and land use will greatly affect the character of the Pond Run watershed. It is anticipated that 28% of the watershed will be in commercial/ industrial use, 53% in residential use, 6% in vacant/agricultural/conservation areas, and 13% in public facilities/streets/other (Figure 3). Under the Master Plan level of development, the population will increase 68 percent. The only public open space within the watershed will be the 254-acre conservation area.

Flooding: Conversion of 40% of the open space in the watershed to residential, commercial and industrial land will greatly increase flood potential. Covering large areas of land with impervious surfaces will significantly increase the rate and volume of runoff. In addition, if existing drainage practices are continued, small open channel tributaries will be replaced by storm sewers and main channels will be enlarged and smoothed. Channelization of the central portion of Pond Run will increase the magnitude of flooding in downstream areas by eliminating the natural mitigative effect provided by the broad flood plain which acts to store and slow floodwaters. To determine the potential impact of unmitigated development on watershed flood potential, a series of scenarios were developed and tested. The three scenarios tested, all of which assumed development levels consistent with the Master Plan, were:

Scenario 1 - Storm sewers installed in all developed areas. No additional watershed channelization. No stormwater management.

Scenario 2 - Storm sewers installed and minor tributaries channelized to contain the 100-year flood. No stormwater management.

Scenario 3 - Conditions similar to Scenario 2 plus all of Pond Run downstream from Hamilton Lake and the entire North Branch, channelized. No stormwater management.

All three Master Plan land use/drainage system modification scenarios result in significant increases in peak flood flow rates. For example, in the vicinity of Barbara Drive, Scenarios 1, 2 and 3 would result in increasing the 100-year flood flow rates by 73, 100 and 400%, respectively. In all three cases, the 10-year flood would be greater than the present 100-year flood flow rate. Even if surface runoff did not increase, channel modification would increase the peak flow by 100 percent. The peak flood flow rates for 3 watershed locations are summarized in Table 2. The loss of flood plain storage area and the improved channel efficiencies created by sewering and channelization in the middle and upper portions of the watershed account for the extremely high peak flows in Scenario 3. The especially broad flood plain along Pond Run acts in a way similar to a flood control dam in reducing downstream peak flow rates. Filling and building in this flood plain would eliminate this storage area.

TABLE 2
SUMMARY OF PEAK FLOOD FLOW RATES FOR FOUR WATERSHED LOCATIONS

	100-Year Flood Discharges (cfs)			
Location	Existing Land Use*	Scenario 1	Scenario 2	Scenario 3
POND RUN				
Barbara Drive	650	1,125	1,180	2,820
Greenwood Avenue	1,660	2,325	2,500	5,040
NORTH BRANCH				
Klockner Boulevard	795	840	1,065	2,030

* Assumes SCS channel improvements completed.

Storm sewering, channelization and flood plain fill are techniques commonly used in Hamilton Township to reduce local flood heights and widths or to raise new development above flood levels. These techniques generally accomplish these goals at the sites where they are constructed. However, as demonstrated by the future scenario analysis, these techniques significantly aggravate the flooding problem in the downstream portions of the watershed.

Water Quality: If development proceeds to Master Plan level without mitigative measures, Pond Run water quality will be degraded. Suspended solids loads to the stream will be increased, especially during construction periods. Not only will this decrease the storage capacity of Hamilton Lake but it will have a deleterious effect on the aquatic community. Benthic organism habitat will be altered and fish eggs may be smothered by the increasing bed load. Light, necessary to sustain the algae community, will be reduced by the increased turbidity levels. A simplified suspended solids analysis showed that a 43% increase over existing loading factors could be anticipated at the Master Plan level of development.

Increased development, especially near the stream corridor, will increase the eutrophication potential of Hamilton Lake and the nutrient levels of all stream segments. Increased runoff to the lake will have a negative effect on the aquatic community and decrease the aesthetic and recreational value of the park. Street contaminants such as lead, hydrocarbons, asbestos fibers and road salts will increase. The addition of industrial land use along the main stem of Pond Run may degrade water quality due to stormwater runoff and point source discharge. Elimination of trees and overhanging vegetation along the stream bank will reduce shade and change the aquatic biological community.

Vegetation: Forests and fields in the Pond Run watershed add to the aesthetics of Hamilton Township. They also provide wildlife habitat and mitigate the effects of erosion. At the Master Plan level of development, a loss of 1,222 acres of forest and 820 acres of field is anticipated. Although some trees will be saved by developers, only 90 acres of forest in Hamilton Lake Park will be available to the public. All pathways presently used for wildlife circulation will be interrupted. Due to the flatness of the area, elimination of major vegetation stands will greatly alter the watershed's visual appearance.

IV. RECOMMENDED MITIGATIVE MEASURES

Description of Mitigative Measures

Overview: The development proposed by the Master Plan will provide extra tax revenue, establish more jobs in the region, and provide needed housing. However, it has demonstrated that adverse impacts will also occur. The purpose of this section is to present and evaluate measures which can reduce adverse impacts to acceptable levels.

The most serious adverse impacts which were identified were:

1. Loss of open space, natural vegetation and wildlife habitats

2. Significantly increased flood problems

3. Degradation of stream and impoundment water quality

4. Change in character of the watershed and potential aesthetic problems

Several mitigative measures were developed and evaluated. Emphasis was placed on two measures which mitigate flooding problems and environmental impacts at the same time: stream corridors and stormwater management measures.

Stream Corridor: As the term is used in this report, stream corridors refer to the area delineated by the 100-year flood plain plus soils with depth to seasonal high water table of less than 1 foot and which are contiguous to the 100-year flood plain. It has been proposed that the land be maintained in its natural state within 100 feet of either side of the stream channel. Allowable uses in this area would be for passive recreation, bicycle and jogging pathways and wastewater interceptor sewer right-of-way. The interceptor sewer should be kept at least 75 feet from the stream to prevent aesthetic problems, excessive erosion, and pollution due to sewer backups, leaks, etc. It is possible that, when laying the wastewater interceptor, a bicycle or walking path could be constructed over the right-of-way. The area between the 100-foot buffer zone and the 100-year flood plain limit could be used for agricultural purposes and recreation. Figure 5 presents a schematic of the proposed stream corridor concept.

Development as proposed in the Master Plan could occur on the contiguous high water table soils. However, the development would be subject to meeting various performance standards. These performance controls would primarily apply to septic tank conditions. If public sewers are provided, any development level would be allowable. If septic tanks are to be relied on, then the standard percolation tests would have to be passed during relatively wet periods, such as December through May. Development should not be permitted on soils which did not pass this more restrictive septic tank criterion unless public sewers are provided.

The flood plain portion of the stream corridor serves to retard flooding by storing stormwater and slowing its velocity of flow. Stormwater storage is accommodated by the unusually broad flood plain area containing numerous land depressions and pockets. Velocity of flow is reduced by the brush, trees and other vegetation located there. Bends in stream channels and irregular topography also impede stormwater velocity and thereby reduce downstream flooding. Flood plains, therefore, serve a purpose similar to a flood control dam.

The natural flood mitigation offered by flood plains makes them poor places to build houses, impervious parking lots and other structures. Additionally, development usually requires channelization* and filling which reduces the storage capacity of the flood plain and results in increased downstream flooding. Impervious areas, such as sidewalks, roads, parking lots and roofs, eliminate flood plain areas which previously absorbed or slowed stormwater flow. Removal of vegetation also adds to increased flood velocity because the "friction" of the flood plain is reduced.

Flood plain vegetation serves to filter water-borne pollutants and sediment from upland areas so that preservation of stream corridor vegetation will result in reduced pollutant loads to the stream. By allowing potentially contaminated rainwater to flow over vegetated areas, percolate into the groundwater, and reach the stream slowly, water quality benefits accrue.

Protecting areas of seasonally high water table also has water quality benefits. In these areas, pollutants from septic tank fields can be transmitted to groundwater and eventually reach the surface water. Increased development on these contiguous high water table soils will not have adverse impacts if sewers are provided to eliminate potential groundwater contamination.

The proposed stream corridor provides wildlife with a source of habitat and food. It also provides the opportunity for recreational activities, such as bike paths, jogging and other open space activities. Another benefit is the improvement in aesthetic conditions. With essentially an almost total loss of woodlands and open space, proposed by the Master Plan, it is important to provide additional areas which can maintain the aesthetic resources of the area.

Stormwater Management: Scenario 1 (Table 2) demonstrated the impact of insufficient stormwater management in the Pond Run watershed. Even if the stream corridors are preserved, flood flow rates will increase by as much as 70% in the downstream portion of the watershed. The channel constructed to protect the densely developed lower watershed will be unable to handle the increased flows and extensive additional flooding will result as development occurs upstream.

To address these problems and reduce the drastic flooding conditions which would result if no mitigative measures are used, many stormwater management measures are needed.

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* Channelization, while not affecting the volume of runoff, does increase the peak rate of runoff. Channelization will usually prevent flooding of the area adjacent to the channelized stream. However, it eliminates the natural flood plain and its associated flood-retarding benefits; flooding problems are merely passed on to downstream residents.

The stormwater management measures include:

- Changes to the land development ordinances (stormwater management component)
- Revised computational techniques for calculating stormwater runoff
- Provision for retention basins capable of managing up to the 100-year storm
- Encouragement of clustering of homes
- Evaluation of potential large-scale off-site detention ponds
- Use of site-specific mitigative measures, such as rooftop storage, and minimizing impervious surfaces

Impacts of Mitigative Measures

Stream Corridors: Providing for a stream corridor (and preventing further channelization) results in over a 50% reduction in flood flows at the Master Plan development level. However, even with this improved condition, the flooding is significantly worse than under existing conditions. If the stormwater management measures explained later are implemented along with the stream corridor, then flooding conditions can be maintained at existing levels. Table 3 shows flooding conditions at two locations within the watershed for existing, Master Plan, and Master Plan with stream corridor conditions.

Table 3
IMPACT OF STREAM CORRIDOR ON FLOODING

Location	Existing Development		Master Plan (as a Mitigative Measure)		Master Plan w/Stream Corridor		Master Plan w/Stream Corridor and Stormwater Management	
	Peak Flow	Elevation	Peak Flow	Elevation	Peak Flow	Elevation	Peak Flow	Elevation
Barbara Drive	650	53	2,280	57	1,130	55	650	53
Greenwood Avenue	1,160	49	5,040	53	2,330	51	1,660	49

Notes:

1. Peak flow in cubic feet per second (cfs)
2. Elevation in feet. Elevation based on completion of SCS channelization project.
3. The Master Plan without the corridor assumes no implementation of the stormwater management measures. Channelization to allow development up to the stream bank for Pond Run downstream from Hamilton Lake, the North Branch, and all tributaries is assumed. The Master Plan with the corridor assumes no channelization. If both stormwater management measures and the stream corridor concept are implemented, no increase in existing flooding is expected, even at ultimate development.

Implementing the stream corridor concept will eliminate future development in the flood plain. According to the Master Plan, an additional 419 acres of flood plain could be developed. At present, there are almost 4,000 acres of undeveloped land available (68% of the watershed), thus prohibiting development in the flood plain will take only about 10% of the developable acreage. Table 4 presents the amount of woodland, open space and developable lands under various development levels. The stream corridor increases woodlands by 250% over that available with complete Master Plan development.

Areas where development would proceed with special performance controls (i.e., contiguous high water table areas) amount to 808 acres. These areas could be developed if sewers were provided or if septic tanks met more rigorous performance criteria.

TABLE 4
IMPACT OF STREAM CORRIDOR ON ENVIRONMENTAL FEATURES

Feature	Acreage Existing	Master Plan	Master Plan w/Stream Corridor
Woodlands	1,112	90	316
Open Space (non-farm)	2,368	400	756
Developable Land	3,195	3,195	2,776

Stormwater Management: To demonstrate the effectiveness of stormwater management measures, the project's stormwater computer model was used to simulate various mitigative alternatives, assuming full development proposed by the Master Plan. Table 3 shows the impact on flooding at Greenwood Avenue and Barbara Drive. If stormwater management is linked with stream corridor protection, existing flooding conditions will not be worsened, even at complete development conditions.

In addition to the obvious flood damage reduction benefits reflected in Table 4, stormwater management measures will reduce the amount of pollutants and eroded sediment entering the stream.

Implementation of Mitigative Measures

General: The program recommended to Hamilton Township to mitigate the potential impacts on the Pond Run watershed of the Master Plan development is based on the following premises:

- Damage-producing floods will continue to occur periodically despite the construction of Hamilton Lake Dam and the SCS channel project. This existing problem will increase significantly as a result of projected Master Plan development.

- Any watershed modifications that result in increases to the frequency and depth of floods are unacceptable.

- Modification of natural stream channels and flood plains to more urbanized land uses will significantly reduce several indices of local environmental quality, including recreation opportunities, water quality, wildlife habitat, and visual amenities.

These premises have been incorporated into a program designed to reduce flooding, minimize environmental impacts, and be fiscally sound. The implementation program has been structured into two critical mitigative measures--Stream Corridor Protection and Stormwater Management.

Stream Corridor Implementation: Prior to establishing and carrying out the stream corridor protection program, several preparatory steps must be taken. Five prerequisites for the implementation of a successful plan have been identified and are described below.

- Ordinanace Modifications

  The provision of the Hamilton Township Land Development Ordinance that that all open channels be designed for the 100-year storm frequency should be revised. This would require a developer with a stream channel on his property to straighten, substantially widen, and remove the vegetation from the channel to increase its capacity to transmit flood water without overtopping. This would eliminate flooding adjacent to the modified channel, but analysis has demonstrated that additional stream channelization upstream from Barbara Drive will increase the peak flow downstream from Kuser Road--the 100-year flood will no longer be contained within the flood control channel and extensive portions of presently protected areas will be inundated. Therefore, it is recommended that this clause be changed to required that stream channels not be modified unless it can be clearly demonstrated that the modification will not increase peak flow rates in downstream sections of the watershed.

- Undelineated Flood Hazard Areas

  None of the maps currently available or in preparation delineate the potential extent of flooding on the head water and tributary sub-watersheds. Recommendations for stream corridor protection extend to these areas; to accomplish this goal, flood plain areas should be determined for the entire watershed. A program to obtain flood plain mapping of these areas will include the preparation of detailed planiometric maps, a hydraulic analysis of each stream, flood plain delineation, and water surface profile preparation. The hydrologic data required for these analyses have already been developed.

- Master Plan Revisions

  The Master Plan's designation of documented flood prone areas will need to be revised. In the Pond Run watershed, there are approximately 420 acres of undeveloped and agricultural flood prone land zoned for residential, commercial, business, and governmental facilities. Following the completion of the flood hazard delineation, this land, which functions as a natural flood reduction area, should be rezoned as conservation areas* and new Master Plan zoning maps should be prepared.

- Corridor Protection Methods

  Completion of the prerequisites outlined above will establish the foundation for the Township to protect the stream corridors. Two alternative methods are described in the following paragraphs: acquisition of the land or establishment of performance standards. Either method, or a combination of both, is suitable.

- Acquisition of Vacant Flood Plain Parcels

  Purchase of privately owned flood prone land is the direct approach for stream corridor protection. This program may begin immediately after the designation of all flood prone land as conservation areas or may be initiated on a lot-by-lot basis as developers submit their sub-division or site plans.

  Of the 420 undeveloped acres located in the 100-year flood plain (excluding existing conservation areas), approximately 75% of the land is privately owned; the remaining 25% is already either owned by the Township or is owned by non-profit institutions. A land acquisition program will require approximately $3 million for the purchase of parcels and portions of parcels in the flood plain.

  An investigation was made of the potential impact on the watershed tax base of not developing the flood plain land to the uses indicated by the Master Plan. This analysis indicated that at full development, the net budget surplus produced by the Pond Run portion of the Township will be $6.6 million. Assuming that no new development takes place in the 420-acre flood prone area, tax revenues for the watershed will still produce a $5.6-million surplus.

  Funding for the flood plain acquisition can be made available from the Township's Capital Improvement Program (CIP), New Jersey Green Acres, or HUD Community Development Block Grants or a combination of these sources. Because it may be assumed that

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* The Township ordinance allows low density single-family residential construction in conservation areas (lots of at least 5 acres in area), as well as farming and recreational activities.

flood plain land will have some recreational uses, its acquisition may be capitalized, which means it would be exempt from the state "Cap Law." In addition, funds currently set aside for drainage improvements could be re-allocated for flood plain acquisition.

The Green Acres Program, administered by the New Jersey Department of Environmental Protection, is designed to assist municipalities in acquiring and/or developing land for open space and recreation purposes. Grants up to 50% of land and development costs are available for parks, recreation areas and conservation open space.

Hamilton Township is already a participant in the Community Development Block Grants/Discretionary Grants program sponsored by the U.S. Department of Housing and Community Development. This program provides grants for a wide range of activities, including acquisition, rehabilitation and construction of certain public works and improvements. The program is eligible for joint funding with related federal and state assistance programs.

- Performance Standards

The second strategy which may be used to implement the stream corridor program is performance standards. As used in this description of stream corridor protection strategies, "performance standards" refers to land development standards that are either stricter than those required by the Township Land Development Ordinance, or are at variance with the existing zoning map. The performance standards apply to all parcels of land which are partially or wholly in the flood plain and those lands contiguous with the flood plain having seasonally high water tables. The portion of a parcel within the 100-year flood plain should not be substantially altered from its natural state; allowable uses include those specified for conservation areas. The remaining portion may be developed provided "appropriate performance standards" are applied.

Many vacant parcels are split between flood plain and non-flood plain areas. When this occurs, the approach should be to transfer either density or intensity of use to the area outside the flood plain. Development under these circumstances should be deemed a "special cluster," with land in the flood plain used for common open space and for fulfilling yard requirements. Such transfer must be approved by the governing body of Hamilton Township after it has been found that such transfer will not adversely affect adjacent neighborhoods.

This approach works well if the portion inside the flood plain is a small percentage of the parcel. When this is the case, the change in density or intensity on the developable portion will not have adverse affects on adjacent land uses. In instances where the split is half and half, or 95% flood plain and 5%

non-flood plain, it is recommended that the Township acquire the entire parcel.

The performance standards to be applied to the contiguous high water table soils outside the flood plain include: erosion and sediment controls as described in Section 522 of the "Land Development Ordinance of the Township of Hamilton"; and more rigorous septic tank testing procedures to guarantee proper performance under all conditions. Testing should take place between December and April when water table levels are highest.

<u>Stormwater Management Implementation</u>: At the present time, the Township utilizes the stormwater detention requirements recommended by Mercer County. Because of the severe flood problem in the Pond Run watershed, it was strongly recommended that the Township adopt its own comprehensive approach to stormwater management. The components of this program were incorporated into the recommendations which follow.

- <u>Design Storm for Detention Basins</u>

  The storm frequency recommended by Mercer County for designing stormwater detention facilities is the 15-year flood.* This requirement may be satisfactory for watersheds which do not have extensive existing flood plain development. Because Pond Run and the North Branch of Pond Run contain extensive developed areas subject to floods, it is recommended that all stormwater management controls be designed so that the peak flow rates (from a 100-year flood) after development be less than or equal to pre-development peak flow rates.

- <u>Area Stormwater Detention Basins</u>

  An alternative to requiring each developer to install detention facilities is the construction of three to five large-scale detention basins. The advantages of this approach include better Township control over stormwater runoff, reduced maintenance requirements and creation of opportunities to reduce existing flooding problems. The watershed stormwater model developed for the current study can be utilized to evaluate the potential retention sites.

  Should large-scale detention facilities prove feasible, the Township could build basins and be reimbursed by upstream developers. An advantage to the developers is that they would not have to set aside a portion of their property for on-site detention facilities. Programs of this type have been implemented elsewhere. A preliminary review of the watershed has

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* A flood of magnitude with a 6.7 percent chance of being equaled or exceeded in any given year.

indicated that only a few potentially suitable sites for large-scale detention facilities remain available. It was recommended that an analysis of this alternative should be made so that appropriate detention pond areas can be reserved.

- Stormwater Management Manual

  A stormwater management handbook should be prepared for use by developers. The manual should contain stormwater management regulations, calculation methodologies and application procedures. The calculation methodology will reflect the modifications to TR-20 and TR-55 (Urban Hydrology for Small watersheds, Technical Release 55 (USDA SCS)) developed during this study.

V. APPLICABILITY TO AREAS OUTSIDE HAMILTON TOWNSHIP

The two principal recommendations designed to mitigate the impacts of potential urban development in the Pond Run Watershed--protection of stream corridors and stormwater management--can be applied to the majority of watersheds in urban and urbanizing areas. The dimensions of the stream corridors and degree of stormwater management proposed for Pond Run are partially a function of the broad flood plain and gently sloping terrain and the existing flood plain development pattern. Although flood plain characteristics and open space opportunities vary considerably, preserving a naturally vegetated stream buffer, prohibiting upstream channelization, prohibiting fill in the flood plain, and applying stormwater management will greatly assist in achieving the goal of sound urban watershed management.

Figure 4
100-Year Flood Hazard Area

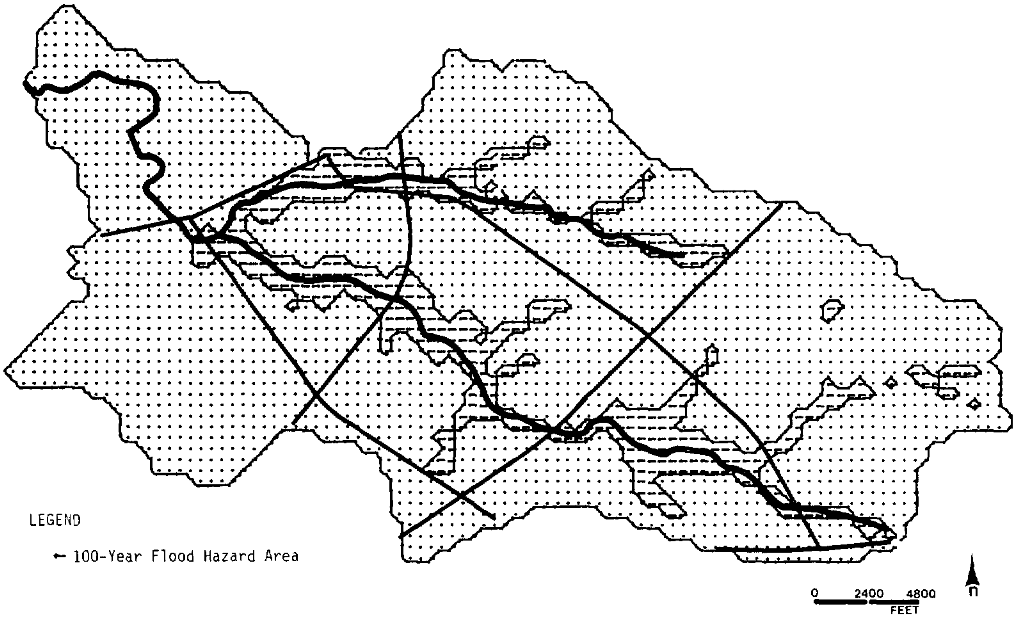
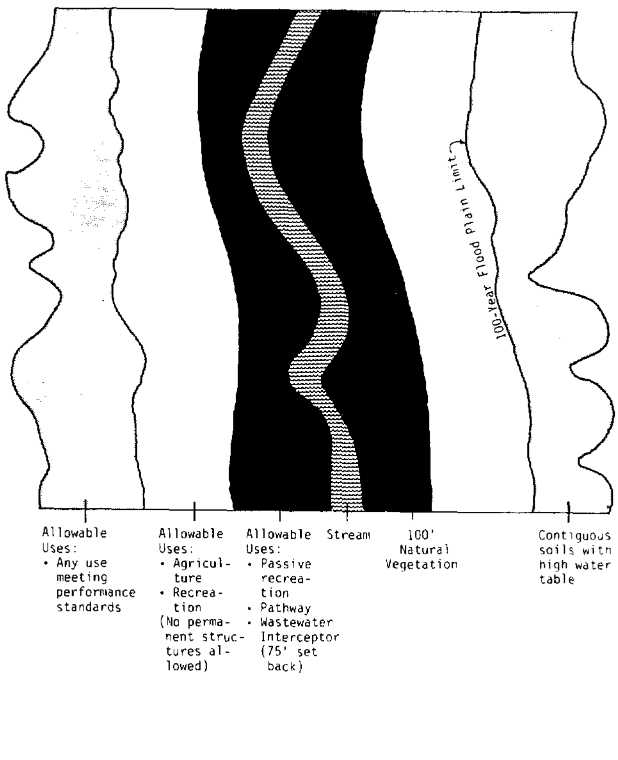


Figure 5
Stream Corridor Schematic



III. CASE EXAMPLES OF SUCCESSFUL PROGRAMS

13

NATURAL DRAINAGE IN THE WOODLANDS

NARENDRA JUNEJA AND JAMES VELTMAN

Wallace, McHarg, Roberts and Todd, Philadelphia, PA and APPLE Design Group, Houston, TX

Background

A little over ten years ago, Mr. George Mitchell expanded his oil and gas corporate interests to include land development. The newly-formed Mitchell Energy and Development Corporation undertook small recreational and development projects around the metropolitan Houston region. Mr. Mitchell, through the inspiration of his own personal leisure activities at his "Woodland Ranch" in Montgomery County, Texas, decided that a more satisfactory suburban living environment was indeed possible than the one afforded by most of the prevailing developments in the region. Assembly of significant acreage initiated planning and design for a 20,000 acre tract, which ultimately has resulted in the Woodlands, a HUD Title VII new community, located 35 miles north of Houston.

It was realized that the magnitude of the undertaking required augmentation of the "in-house" staff capabilities of Messrs. James McAlister, David Hendricks and Robert Hartsfield. A professional planning team was assembled to work with the staff of the Mitchell Energy and Development Corporation to realize Mr. Mitchell's insistent objective that the proposed development plan be comprehensive, innovative and bring to the real estate market a better product that would respect the land and its natural amenities, while ensuring that it is fully marketable in the Houston region. The professional consultant team was comprised of:

- Mitchell Energy and Development Corporation: Staff Coordination
- William L. Periera and Associates: Master Planning
- Wallace McHarg Roberts and Todd: Ecological Planning
- Robert Gladstone and Associates: Market Research
- Richard P. Brown and Associates: Engineering and Master Planning Assistance

The professional team utilized the services of a number of specialist consultants during the various stages of planning and design.

The attraction of the Woodlands site for development derives from two complimentary locational attributes. Firstly, it is located athwart the major interstate highway leading northwards from Houston and the airport. Secondly, it is a gatepost into the only extensive natural forest in the region. (Fig. 1) The desire of exploiting this rich and diverse resource as a woodlands setting for human occupancy must ensure that the necessary artifacts, viz houses, roads and utilities, are so located and designed that enough of the Woodlands endure in good health. Even the most cursory examination reveals the necessity for developing some innovative strategies, if this objective is to be realized. The natural forest types have evolved within the ecological context of a humid, subtropical climatic regimen operating over relatively recently emerged geologic formations of the Gulf

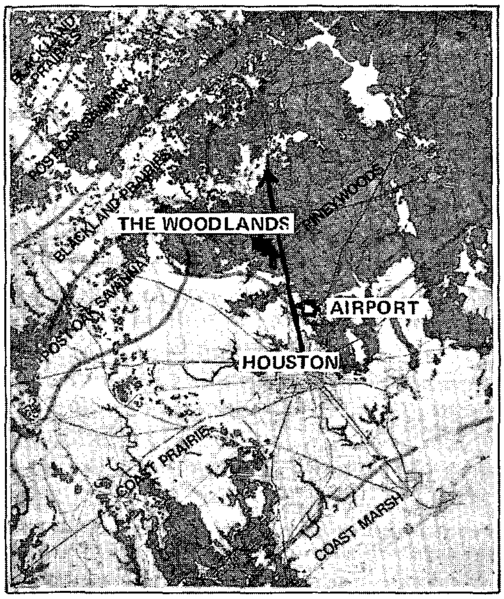
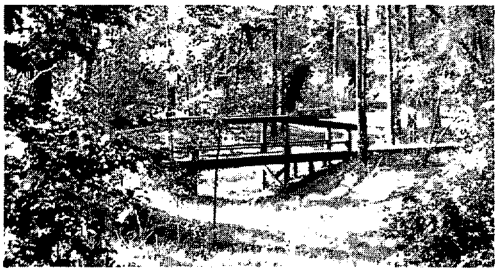


Fig. 1 Regional Context

Woodlands–prior to development



The Woodlands

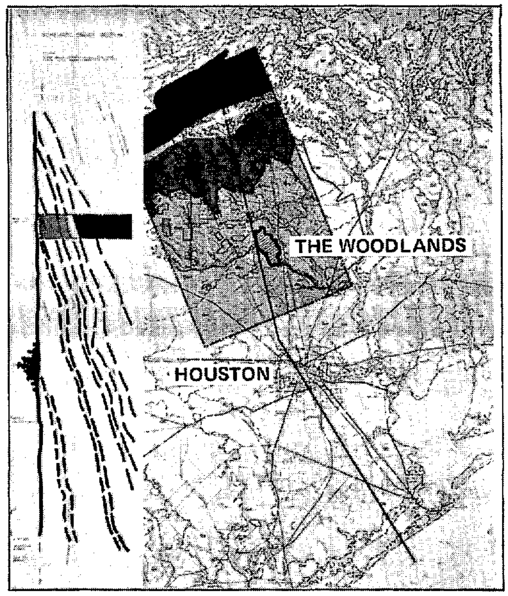


Fig. 3 Regional Aquifers

Coastal Plain. The interaction of these two major elements has produced an extremely flat topography and fine textured, highly leached, palendults soils. (Fig. 2) Poor drainage and extensive surface flooding is the regional characteristic which at once supports the natural woodlands and, simultaneously, represents anathema to human occupants who, as a rule, prefer to live with dry feet. A strategy was required to permit adequate dryness to accommodate the needs of projected human population in the Woodlands in close juxtaposition with the saturated conditions required for survival of the desirable woodlands.

The necessity for development of such an adaptive strategy is further reinforced by the recognition of the vulnerability of another major natural resource–water. The prevailing climatic and geologic regimens produce a sparse surface network of streams which are characterized by low base flow and very high peak flows. Surface storage of water in reservoirs is at the cost of pre-emption of land area and also subject to wasteful high evaporative losses. On the other hand, the same operative natural processes have produced a bountiful availability of sub-surface water. The unconsolidated sand, gravel, silt and clay geologic formations, saturated with water, extend uniformly throughout the region. Their downward dip towards the Gulf Coast enables perpetual recharge over the outcrop areas in the northwest and potential withdrawals of substantive amounts under artesian conditions in the southeast. (Fig. 3) This resource value can be sustained as long as the two ends are maintained in balance. Not only regulation of withdrawals is required, but it is important to ensure adequate recharge

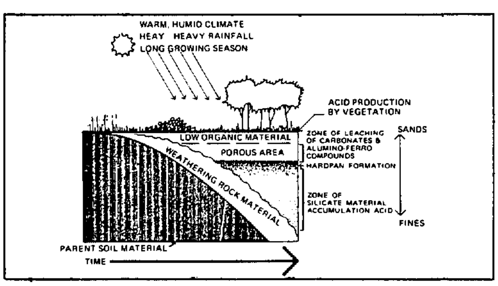


Fig. 2 Regional Pedology

Typical surface flooding

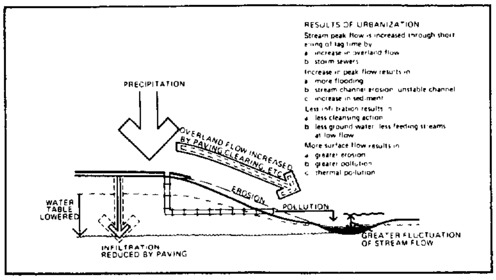


Fig. 4 Typical Urbanization Effects

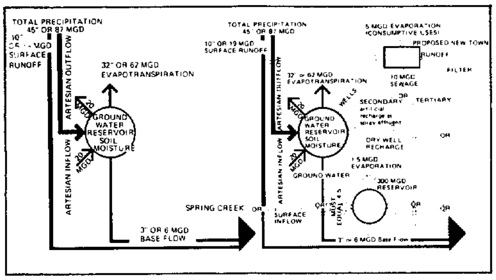


Fig. 5 Water Budgets

within the outcrop areas. Orthodox development practices prevent recharge function to occur through extensive paving, compaction and the attendant drainage "improvements" whereby the water is moved rapidly over the surface and through conduits. (Fig. 4) In addition to resource depletion, this dewatering of subsurface formations also increases the hazard of surface subsidence. Previous unregulated practices in the region have indeed produced subsidence in Houston.

First General Plan

The Woodlands planning started with a detailed ecological inventory[1] and a parallel market study which identified both the numbers and types of development to be accommodated on the site. First major matching of resource and demand was accomplished through development of water budgets for the existing undeveloped condition and for the projected total future population. (Fig. 5) The latter provided for withdrawal of 15 mgd from the aquifers from evenly dispersed wells. This amount is well within the estimated 20 mgd flow through the principal artesian aquifer beneath the site. To ensure that the eventual water lost from the system is held to a minimum, a commitment was made to return most of the withdrawn amount (10 mgd remaining after estimated consumption losses of 5 mgd) back into the ground through surface application of treated effluent. Additionally, it was decided to utilize no storm sewer system. All surface runoff was to be handled through retention at the ground surface. This will permit its recharge into the ground or allow graduated flow through existing drainage channels. (Fig. 6)

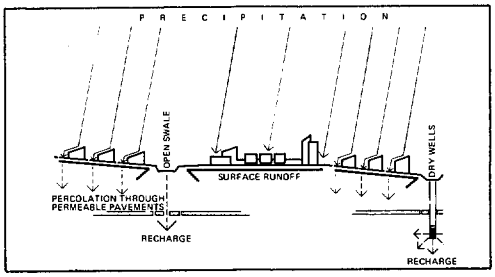


Fig. 6 Proposed Recharge of Runoff

The operation of such "natural" drainage system required a careful examination of the natural runoff conditions on the site. Then prospective development could be related to it to ensure ideally a minimum change from the natural condition, or to identify the magnitude of compensatory action required to restore the natural balance. Among the three major contributors in runoff production, the incident precipitation is a fixed entity which remains unchanged. The existing condition is uniformly forested and thus the ideal state for minimizing runoff. Except for some exceptional quality stands which require protection for their intrinsic ecological value, the remainder of forest provides no guide for prospective development as all development will result in pronounced runoff increase, modified only slightly by its own characteristic cover combinations in the developed state. The last contributor in runoff production is the permeable nature of the ground surface itself. This is the most variable factor, both in the natural state due to soils variability and in the developed state due to the variable amount of impervious surfaces associated with different development types. In the Woodlands site, soils range from relatively impervious (Sorter with Soils Index of .2) to highly porous (Boy, Leefield and Fuqua with Soil Index of 20). Prospective residential development types range from

Fig. 7 Surface Recharge Potential

Darkest tones represent highly permeable soils, absence of tone is representative of impervious soils, while middle gray tones represent intermediate recharge value. Major floodplains are in heavy outline.

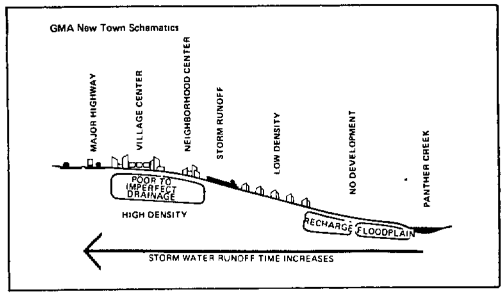


Fig. 8 Development for Effective Recharge

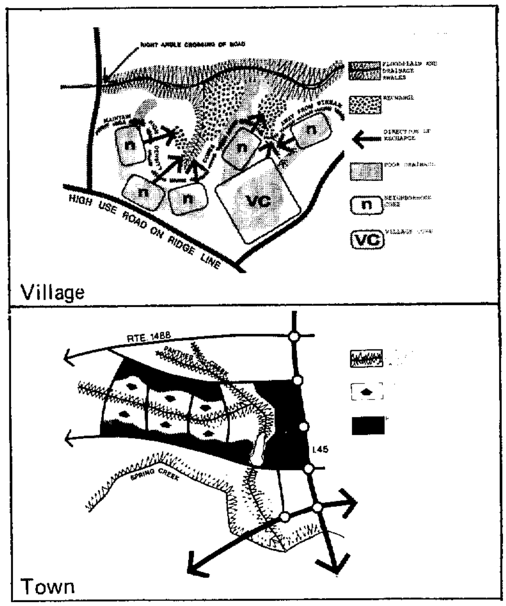


Fig. 9 Conceptual Development Plans

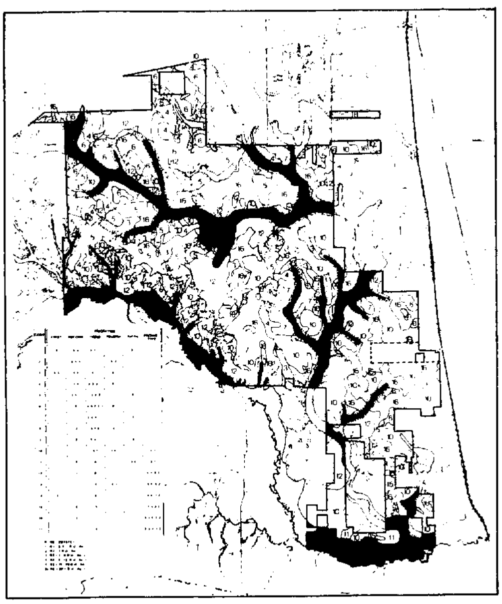


Fig. 10 Synthesis: Development Opportunities

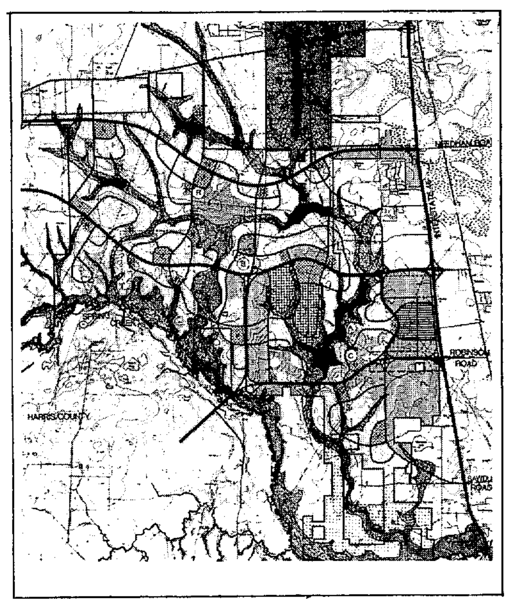


Fig. 11 General Plan

from 22.5% impervious surface (single family detached) to 55% (attached townhouses); while commercial areas may approximate 100% coverage.

Interpretation of soils data revealed that the most permeable soils generally occur at lower elevations along the floodplains, the most impervious soils occupy the flat uplands, and intermediate recharge soils occur on sloping areas in between. Overlaying this distribution with drainage area boundaries enabled identification of a generalized development pattern which located higher intensity development on higher elevations. (Fig.7) As this is coincident with impermeable soils which produce higher runoff in the natural state, lesser amount of excess runoff will result through their development. Less intensive development on the intermediate slopes and reservation of high recharge soils next to floodplains as community open space would permit most of the excess runoff generated to be recharged within individual drainage basins. (Fig. 8) Aggregation of excess runoff throughout the site will be avoided and distributed recharge along the floodplains will help moderate stream flows. The distribution of development densities also conforms with the social objective of the overall town to comprise of discrete "village" clusters. (Fig. 9)

Interpretation and synthesis of all other natural, (Fig. 10) social and economic factors led to the development of the First General Plan. (Fig. 11) The Plan[2] received approval of the Department of Housing and Urban Development (HUD), which granted it a guaranteed loan under its Title VII program.[3] Review of market factors led to demarcation of the southeast corner of the site as the most opportune location for the first stage development. Market factors also led to the necessity of modifying the land uses allocated to this part of the site in the General Plan. Essentially, higher magnitude of residential development complemented by commercial recreation facilities was required to be accommodated.

Phase I Plan

The detailed planning of Phase I began with detailed data inventory at a scale commensurate with its 1900 acres extent. The previous investigation for the overall 20,000 acres had already signalled that the southeast portion of the site was relatively limited in terms of runoff management opportunities. The enormity of the problem became manifest when detailed topography and soils data became available. Substantial parts of Phase I site area are occupied by impermeable soils and have very low surface gradients. (Fig. 12) The commitment to a "natural" drainage system faced a very difficult challenge.

The adaptive solution emerged through detailed site investigation when it was observed that although the overall gradients were low, at the micro level slight elevational changes were discernible. Further observations revealed that these micro topographic variations are coincident with soil type interfaces. Often, the more permeable soil types (Boy) displayed a higher relief and gradient compared to adjacent excessively flat impermeable soils (Splendora). The next observation logically reinforced the universal adaptive principle that

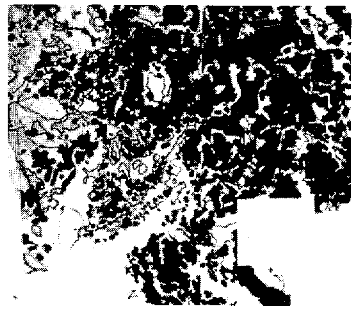


Fig. 12 Impermeable & Poor Surface Drainage

the most stressful environment (frequent flooding contrasting with low moisture availability during dry episodes) represented by the flat impervious soils was occupied by vegetation of low diversity, while the more equable environment of Boy soils supported the densest and most diverse vegetation type. The adaptive solution evolved to suggest utilization of these soil interfaces as primary recharge zones through their preservation as open space elements to which most of the surface drainage from adjacent impermeable surfaces is directed. (Fig. 13) A variety of design strategies were developed to make this possible. (Fig. 14) The general implication of extensive development over impermeable soils and its absence from the permeable soils is consonant with the objective of woodlands protection as the poorer less

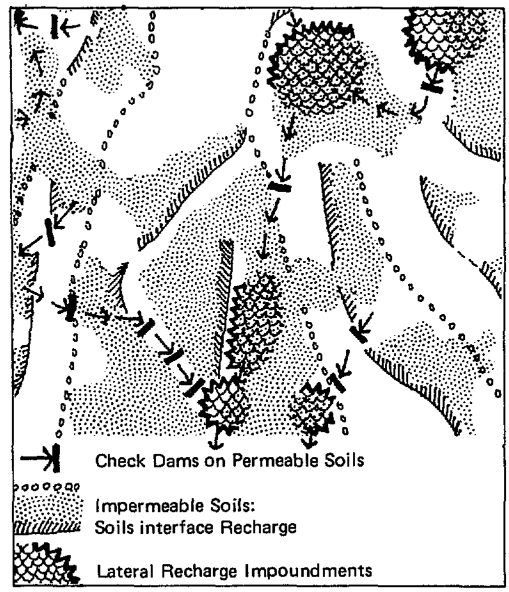


Fig. 13 Detail: Recharge Strategy

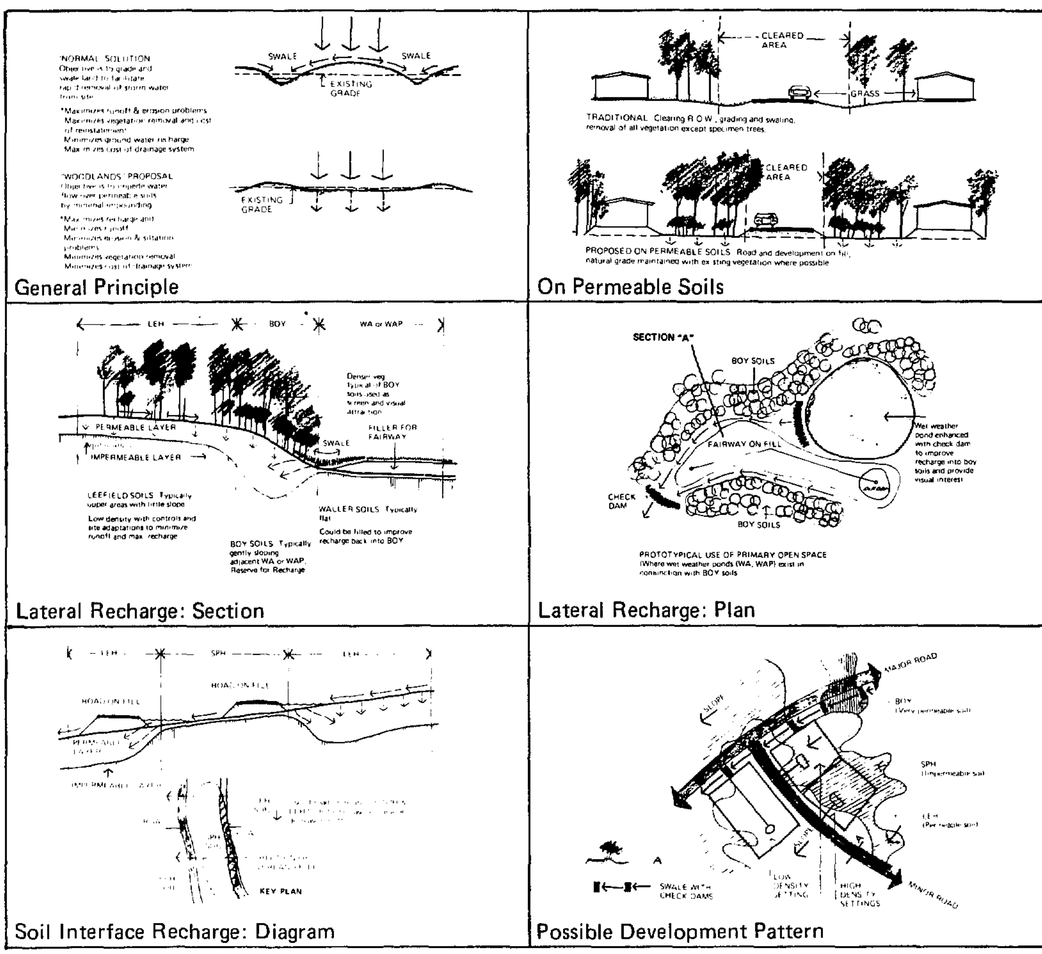


Fig. 14 Adaptive Design Strategies

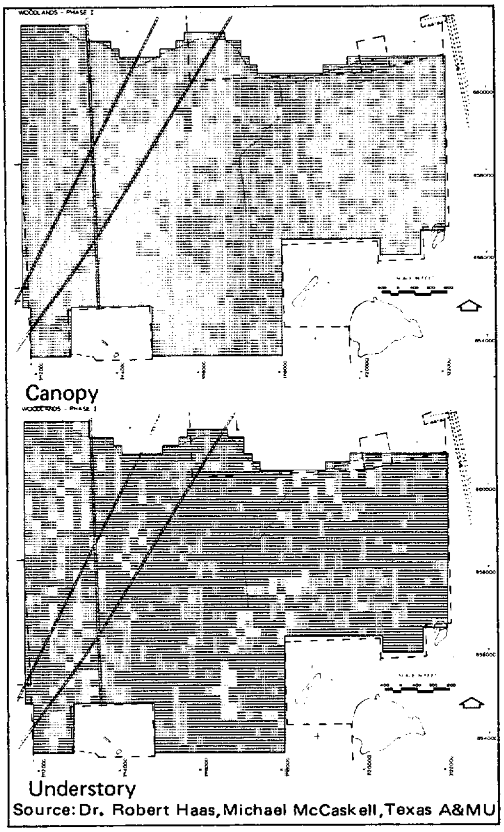


Fig. 15 Vegetation Mapping

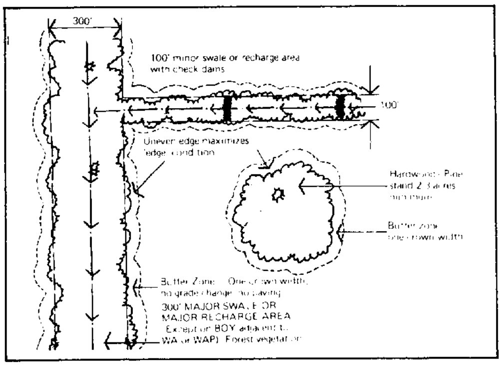


Fig. 16 Vegetation Protection

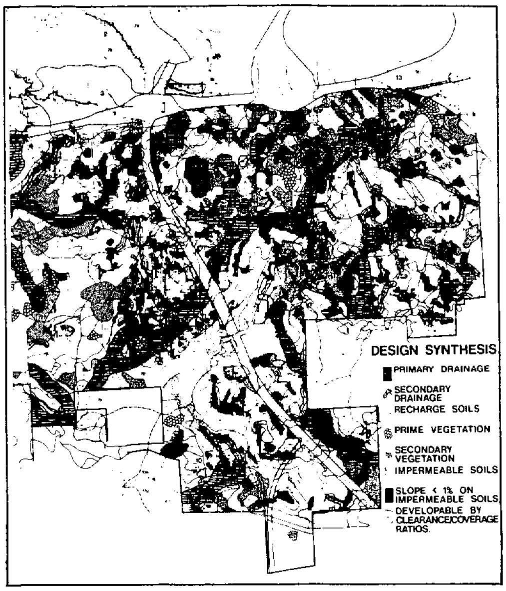


Fig. 17 Phase I Synthesis

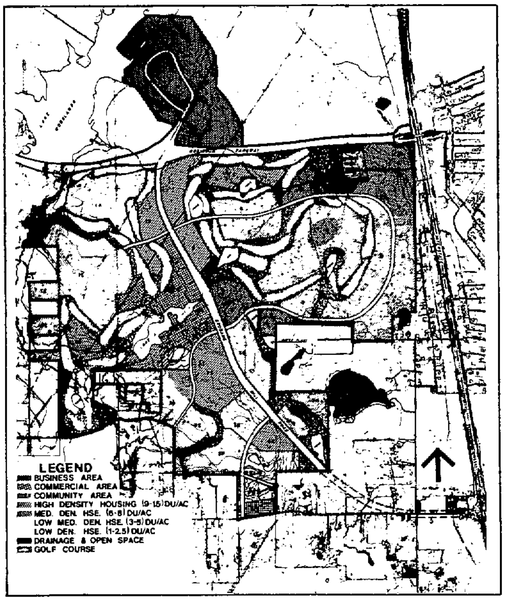
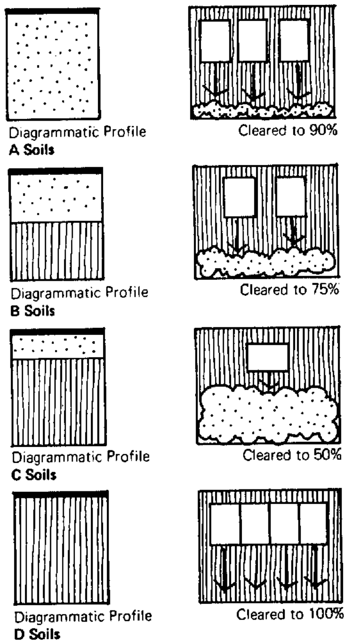


Fig. 18 Phase I Plan

diverse vegetation types are subjected to a higher pressure for removal.

Once the concept had emerged, it was very carefully related to detailed site application. Rigorous vegetation surveys (Fig.15) enabled refined delineation of site types for various development intensities; and at the same time permitted identification of highly valued species as well as stands for protection. Minimum stand sizes and configurations could be inferred to ensure their survival as viable woodlands. (Fig. 16)

The overall plan development for Phase I[4] started with special delineation of floodplains along major drainage channels, high recharge soils and vegetation stands of the highest quality, (Fig. 17), all of which are precluded from development. Next,



Soil Group	Soil Types	Capacity	% Area that can be made Impermeable
A	Lakeland, Eustis	High	90%
B	Boy, Albany	Medium	75%
C	Fuquay, Lucy, Leefield, Bruno, Wicksburg	Low	50%
D	Angie, Crowley, Segno, Sorter, Splendora, Susquehanna, Waller	None	100% (effectively impermeable under present conditions)

Fig. 19 Permitted Coverage

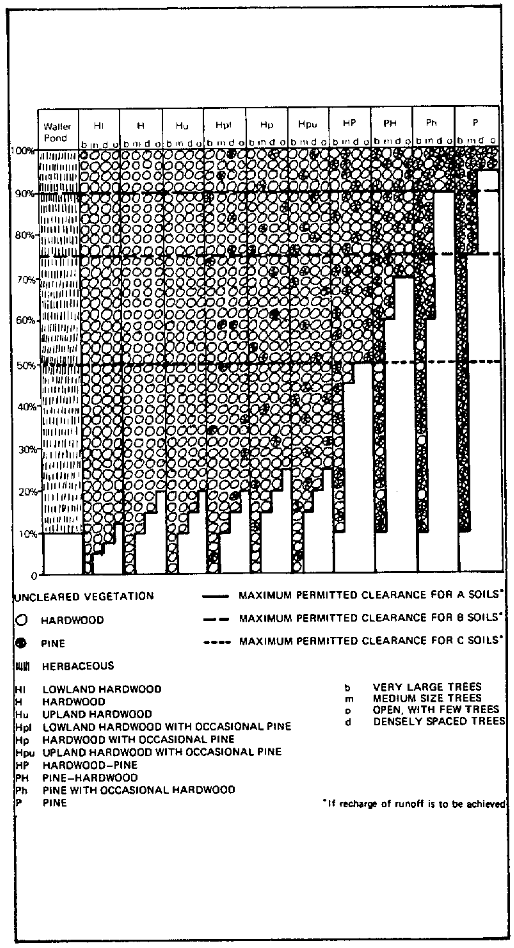


Fig. 20 Permitted Clearance

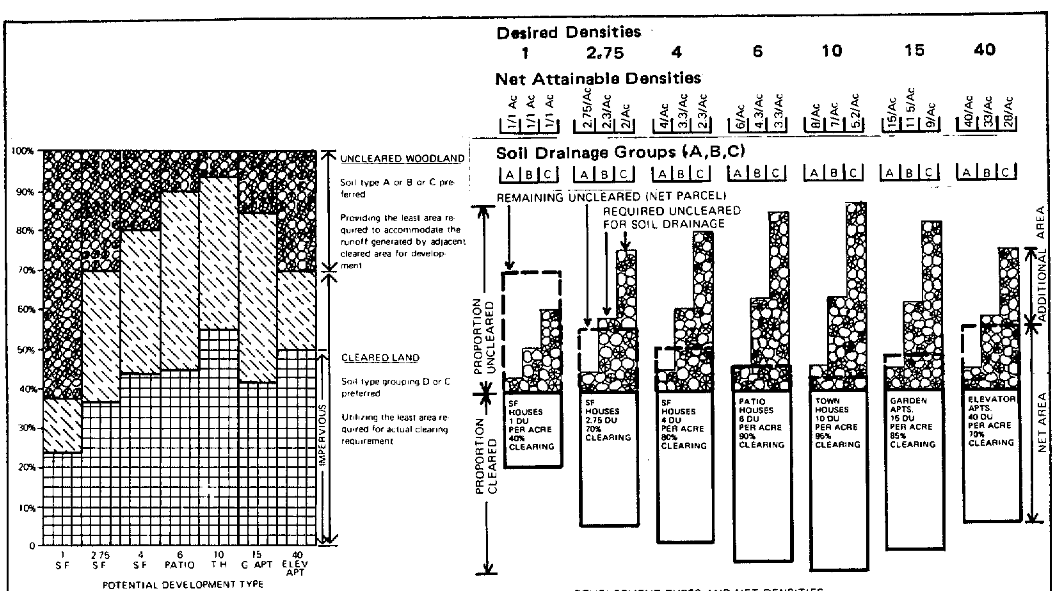


Fig. 21 Development Types' Clearance/Coverage Requirement and Accommodation

major infrastructural elements, i.e., roads and golf fairways, are located to direct drainage towards high recharge areas. (Fig. 18) Finally, design guidelines are developed to ensure that the intensity of development is in response to the localized recharge potential (Fig. 19) through limiting the amount of site coverage (impervious area) and to the localized vegetation through limiting the amount of site clearance. (Fig. 20) The coverage/clearance combinations are related to the marketable development types to determine their spatial allocation. (Fig. 21) For detailed site design, a handbook of design guidelines[5] is made available which permits the individual developer /designer to replicate the process at the scale of his own development area. (Fig. 22)

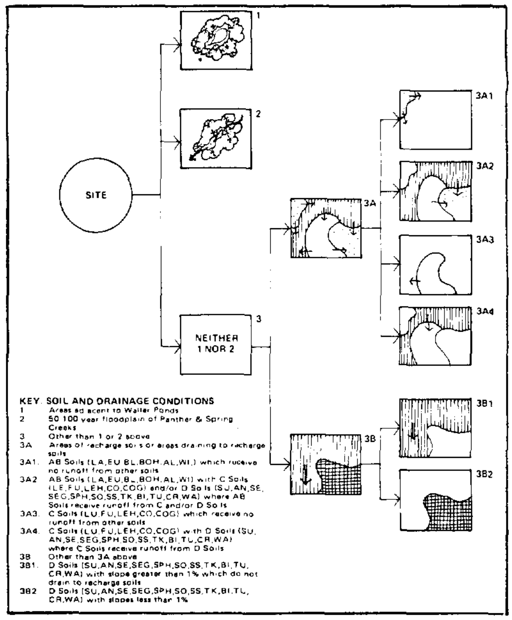


Fig. 22 Design Guidelines Key

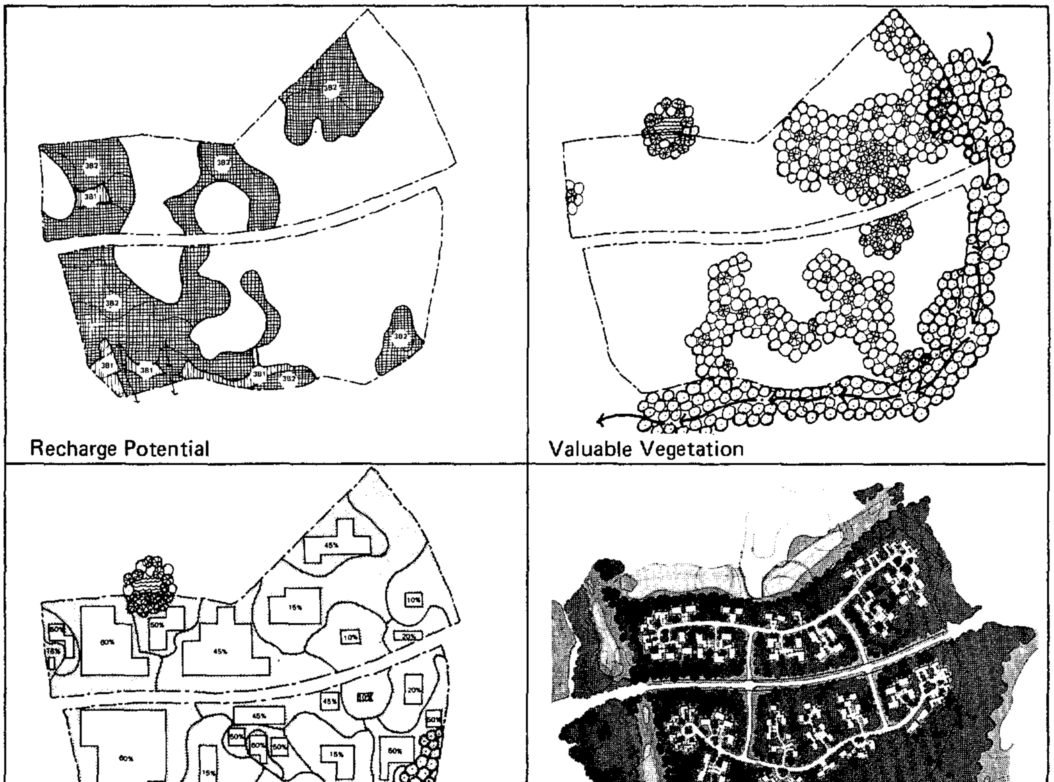


Fig. 23 Design Guides Application

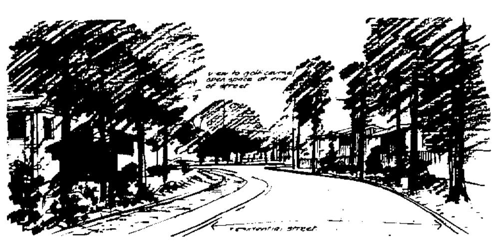
Realization

The methodology and use of design guidelines is demonstrated through its application to a 48-acre development parcel within Phase I. The parcel is bisected by a minor collector and surrounded on three sides by the golf course. The program calls for accommodation of 113 units. Selected illustrations of the stepped procedure are included here. (Fig. 23) Photographs are of already built similar situations elsewhere within Phase I.

A more dramatically successful instance of design application and its realization is illustrated and was an experiment on the part of the developer. A six-acre tract of land was divided into 6-one (1) acre private drive "cul-de-sacs." The first one acre tract was planned with 6 single family detached houses, planned and laid out along a twenty-foot wide private drive. This plan, developed by one of the authors while he was Director of Environmental Planning at the Woodlands Development Corporation, involved several key elements. The first major factor was tree preservation, therefore all foundations were designed as pier and beam foundations—a unique innovation, in contrast to the typical building methods in the region.

The second factor was controlled clearing and freedom to change building locations on actual site based upon local tree locations with site clearance to be kept to a minimum (2 feet outside of foundation lines). The third factor was drainage, which was intentionally no site drainage, because

Collector Street

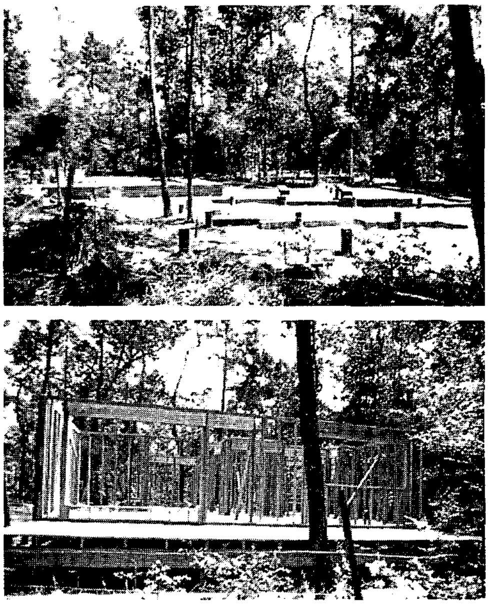


Residential Street

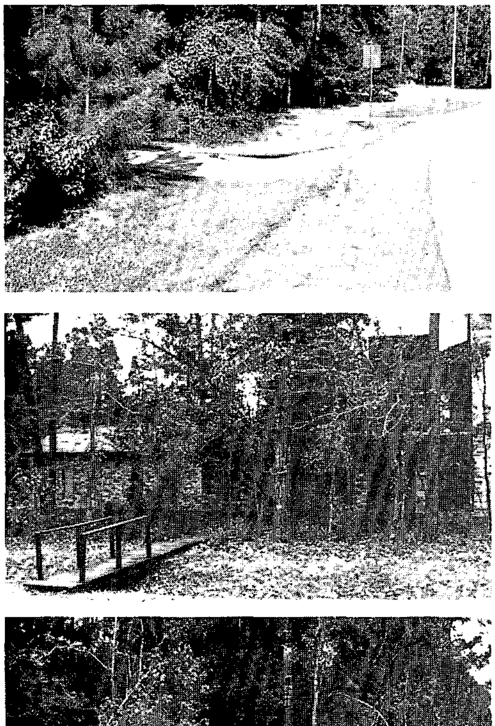
Cul-de-Sac

of soil conditions (Boy soils) except draining of the driveway. The fourth factor was total restriction of site grading. The existing condition was retained for minimum tree root disturbance and lastly, no lawn areas were to be allowed. All landscaping would utilize native woodland species.

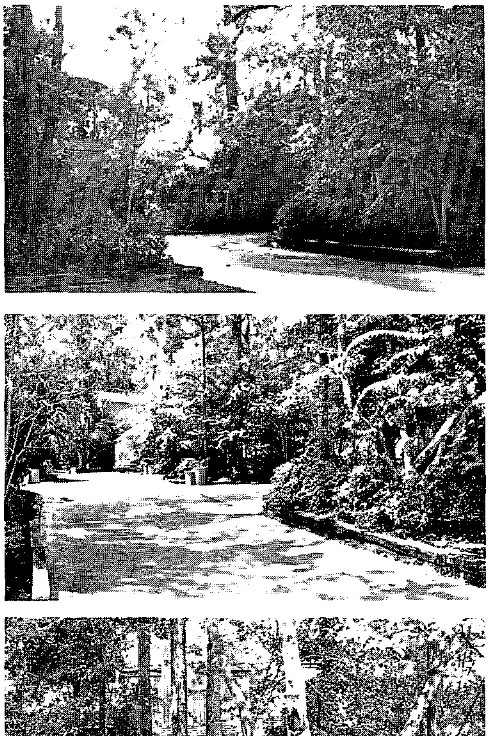
Site layout and construction scheduling were carefully developed on the site itself. The architect for the residences, Charles Tapley, was assisted in the siting of the dwelling units and now, five years later, the finished reality belies the fact that it is a very intensive development of six single family detached units per acre, that drain sufficiently and have preserved the character of the original Southern Piney forest.



Pier-beam foundations and limited clearance



Individual variations for recharge Swale crossing



Finished reality

Evaluation

All stages of the Woodlands planning and design development have been based upon excellent data and subjected to rigorous analysis. The technical aspects of storm water management were dealt with by Messrs. D.E. Winslow and W.H. Espey, Jr. A monitoring project was funded by the Municipal Environmental Research Laboratory, U.S. Environmental Protection Agency and conducted by the Department of Environmental Science and Engineering, Rice University, Houston Texas, to focus on methods maximizing the use of water resources in a planned urban environment, while minimizing their degradation. Summary reporting of these is presented here.

Winslow and Espey developed a model[6] to identify Storm Runoff Hydrograph as part of the General Plan evaluation. The model employed formulae developed by them based upon empirical observations of five watersheds in the Houston region. The method consists of developing unit hydrograph for a given drainage basin in the form of a runoff hydrograph resulting from one inch of rainfall excess (i.e., runoff) falling at uniform rate over the entire drainage area for a specified duration of 30 minutes. By developing such unit hydrographs for each 30 minute increment of the total runoff from a given storm rainfall event and summing them up a total runoff hydrograph for the particular storm can be obtained. For the Woodlands, an assumed 1 square mile of circular drainage area, with slope and length of main channel equal to the diameter of the circle and under existing natural conditions of heavy vegetation yielded a peak discharge of 315 cfs for a 25-year, 6-hour storm (6 inches in 6 hours, with 3 inches falling within the first 30 minutes). It was further assumed that the drainage area is underlain by Splendora Soils with soil index (maximum permeability in inches/hour) of 2.0, the soil moisture index (i.e., antecedent precipitation index) is fairly moist and the drainage area is undeveloped. Superimposing a uniform development layout pattern (Fig. 24) of varying intensities (impervious percentage from 22.6 to 34.7) produces increased peak discharges (from the base

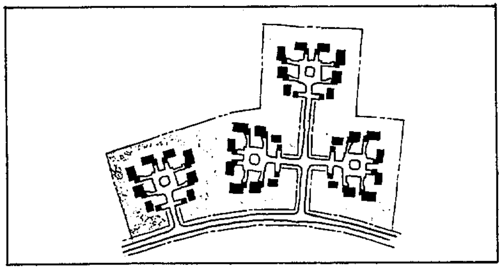
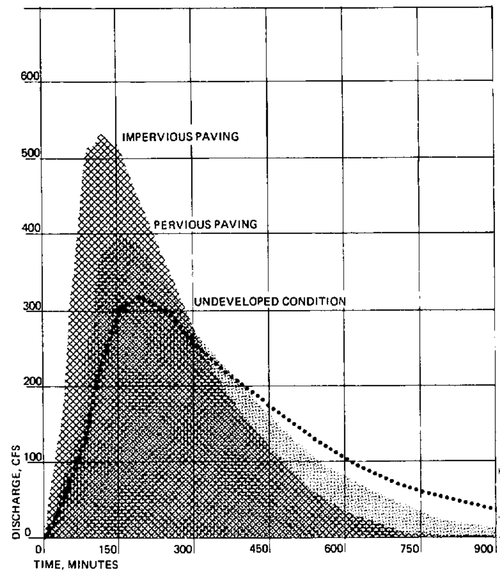
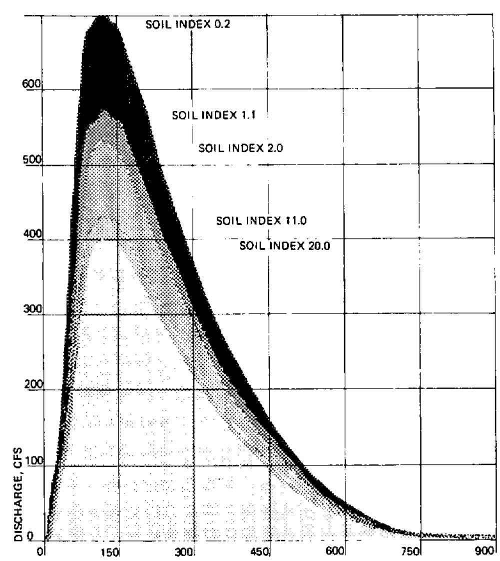


Fig. 24



Adapted from Winslow and Espey.[6]

Fig. 25



Adapted from Winslow and Espey.[6]

Fig. 26

discharge of 315 cfs) of 60 to 100%. The 60% increase resulting from single family detached development (4 du/acre) is illustrated here. (Fig. 25) Related increases in water quality parameters are 40-70% for suspended solids, 35-65% for nitrates, 20-40% for COD and 65-120% for fecal streptococcus.

Holding all other parameters except the soil type constant, the hydrograph variations for the previously illustrated single family development type show remarkable variations. The illustrated hydrographs (Fig. 26) are related to the following soil conditions within the drainage area:

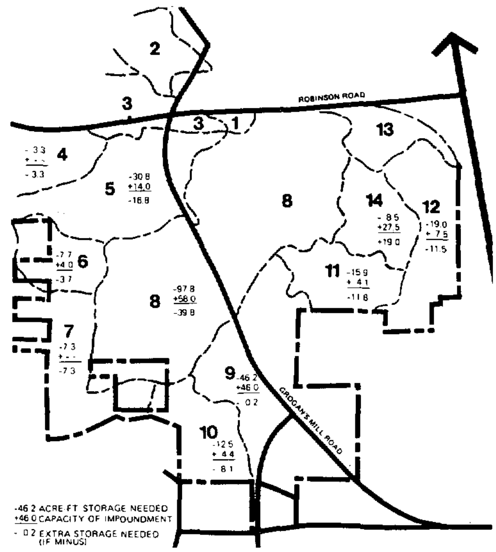
Soil Index	Soil Type	Increased Peak Discharge
20.0	Boy, Leefield, Fuqua	Base
11.0	50% Splendora, 50% Boy	7%
2.0	Splendora, Waller	33%
1.1	50% Splendora, 50% Sorter	43%
0.2	Sorter	76%

The modelled water quality parameters show parallel increases. The advantage of locating various development types on appropriate soil types are amply demonstrated.

Finally, another variation was attempted to test the efficacy of selecting porous paving for streets and drives in lieu of impervious paving. Peak discharge reduction of 26% and water quality improvements of 10-30% resulted. (Fig. 25)

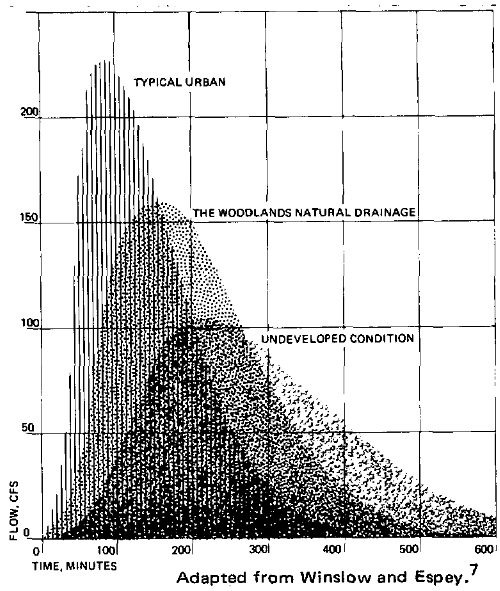
During Phase I planning, the model was refined[7] to take into account the planned concept of sub-drainage areas within larger units. The previous procedure was modified to develop hydrographs for each sub-drainage area. For each sub-area, specific soils occurrence determined the soil indices employed. (Fig. 27) The accumulation of sub-area hydrographs accounted for lag time while routing down the main channel. In summary, the following improvements were noted in the percentage increases from the base natural conditions:

Parameter	Single Unit Drainage Area	Accumulated Sub-Drainage Areas
Peak discharge	60-100	40-75
Suspended solids	40-70	30-55
Nitrates	35-65	20-50
COD	20-40	15-35
Fecal Streptococcus	65-120	50-100



Watershed	Total Area (.9 ac. units)	Permeable Soils (in .9 ac. units)	% to Total	Impermeable Soils (in .9 ac. units)	% to Total	Watershed as % of Phase I Area
1	18.07	12.00	66.5	6.07	33.5	1
3	10.67	7.35	68.9	3.32	33.1	1
4	33.78	31.78	94.1	2.00	5.9	2
5	226.83	134.33	59.3	92.50	40.7	13
6	53.75	41.20	76.6	12.55	23.4	3
7	70.94	56.64	79.8	14.30	20.2	4
8	534.31	326.55	71.1	207.76	28.9	30
9	327.22	202.40	61.8	124.82	38.2	19
10	73.13	51.25	70.0	21.88	30.0	4
11	95.83	56.00	58.4	39.83	41.6	5
12	153.05	83.00	54.2	70.05	45.8	9
13	77.77	50.00	64.2	27.77	35.8	4
14	91.21	55.00	60.0	36.21	40.0	5
Total	1766.56	1107.50	63%	659.06	37%	100%
13A	32.04	16.50	51.4	15.54	48.6	

Fig. 27 Phase I Subdrainage Areas



Adapted from Winslow and Espey.[7]

Fig. 28 "Natural" vs. Typical Drainage

It is obvious that further subdivisions within the tested sub-drainage areas and allocations of development over more appropriate soil complexes would produce improved results.

A summary run of the model for all of Phase I revealed that a 55% increase in peak discharge could be anticipated. This contrasts with experienced 180% increases resulting from the current "normal" development practices in Houston. (Fig. 28)

The monitoring research project[8] by Rice University team undertook a massive sampling and monitoring program for a period extending from January 1975 to April 1976. Rainfall, streamflow and over twenty five water quality parameters were monitored on a regular basis. Within the Woodlands one study site was selected to the north of Phase I area, while the other was located at the discharge point from the Phase I area, parts of which were under construction during the course of the study. Two additional study sites were located at each lower end of the two man-made lakes within Phase I Commercial, Leisure and Recreation Center. For comparison two other urbanized sites within Houston were studied during the same period. A parallel study monitored the performance of an experimental porous pavement (parking lot) within the Woodlands.

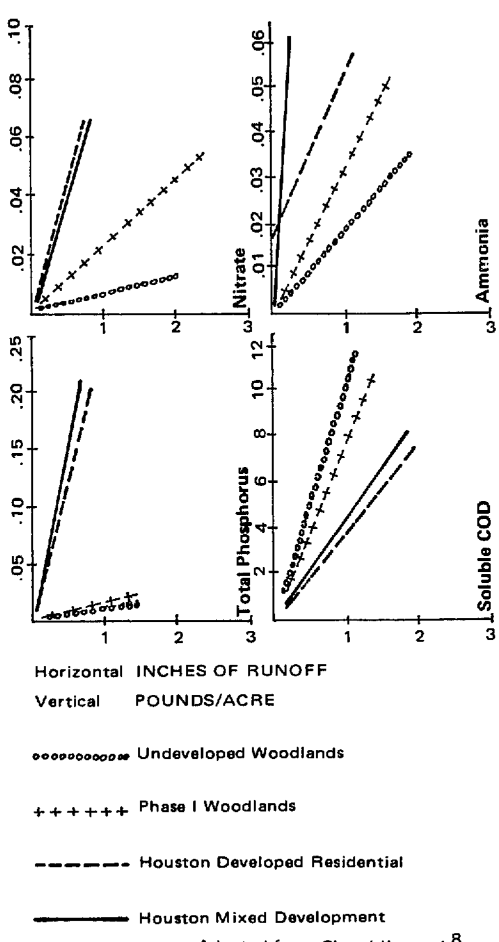


Fig. 29 Load-Runoff Relationships

A selected representation (Fig. 29) of "the pattern of nutrient response for the urban developing and forested watersheds is distinctive, with the urban response producing loads up to an order of magnitude larger."[9]

Another salient finding of the study indicates that significant portion of runoff pollutant loads of phosphates, nitrogen and COD are directly attributable to the quality of rainwater. The capability of undisturbed soils to remove these nutrients is severely diminished when these are disturbed by development. Also, a linear relationship exists between total pollutant loads and total stormwater runoff. It can be inferred, that the withholding of runoff by the Woodlands "natural" drainage and minimization of "disturbed" areas are extremely valuable in improving stormwater quality. The study findings also confirm the beneficial value of porous pavings in performing this task.

The ultimate test of any innovation must finally be made by the people themselves. The developer, Woodlands Development Corporation (and HUD), foresaw a projected savings of $14,478,900 when it

High-rise commercial under construction

undertook to adopt a "natural" drainage system instead of a conventional storm sewer system, the cost of which was estimated to be $18,679,300. It has not been possible to ascertain what portion of the anticipated $4,200,400 to be spent for all of the Woodlands for the innovative drainage system have been spent. But, the system has withstood the onslaught of many a storm, including a record of 9" in 5 hours as recently as April 18, 1979, when no house within the Woodlands flooded while all adjacent subdivisions were awash.

In addition to the cost and safety factors, the proposal was viewed with forebodings about the unacceptability of the resultant landscape which offered diverse woodlands instead of customary manicured lawns and few decorous trees. The booming success and popularity of the Woodlands in the Houston region are ample testimony that those fears were indeed untrue. The following statements are offered as attestations:

Charles Kelley, local real estate broker, "It is becoming more apparent that the storm sewer systems are creating inherent problems and there is a growing awareness of the adequacy of the natural drainage system because of its performance during extreme storm conditions."

David Franklin, builder, "We do have typical developer problems, but having built and lived here for four years, the efforts are visible even in the lower-priced layouts."

John Standish, resident, "It was well worth it. We moved to the Woodlands especially because of the planning effort involved. Can't say much for the builders, but the land plan and overall drainage and tree preservation makes any builder's house in the Woodlands worth it."

Don Gebert, resident,"We've never had problems with our area. We love it, especially the greenbelt behind our house. Must be it was planned well. Think it's great."

Recharge/holding pond in golf course

Porous private drive

Swale at end of private drive

1. Wallace McHarg Roberts and Todd; **Woodlands New Community: An Ecological Inventory.**
2. ; **Woodlands New Community: An Ecological Plan.**
3. Department of Housing and Urban Development; **Project Agreement Between the United States of America and the Woodlands Development Corporation;** August 1972.
4. Wallace McHarg Roberts and Todd; **Woodlands New Community: Phase One: Land Planning and Design Principles.**
5. ; **Woodlands New Community: Guidelines for Site Planning.**
6. Winslow, D.E. and Espey, W.J., Jr.; **Storm Runoff Analysis of Residential Settings for the Woodlands;** TRACOR Project 077-022-01, Document No. T72-AU-9585-U; September 1972.
7. ; **Storm Water Quality Analysis: Phase I: The Woodlands;** Espey, Huston & Associates, Document No. 7302-R1, EH&A Job No. 0011; May 1973.
8. Charaklis, William G.; Gaudet, Frank J.; Roe, Frank L. and Bedient, Philip B.; **Maximum Utilization of Water Resources in a Planned Community,** Executive Summary; Grant No. 802433 to the Department of Environmental Science and Engineering, Rice University, Houston, Texas; Municipal Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency; (undated) Work completed December 31, 1976.
9. Ibid.

IMPLEMENTATION OF STORMWATER MANAGEMENT IN A CANADIAN MUNICIPALITY: THE MARKHAM EXPERIENCE WITH SITE TAILORED CRITERIA

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I. INTRODUCTION

Runoff-control from new developments by means of Storm Water Management (SWM) measures has become increasingly accepted in North America. Its role is to minimize the effects of hydrologic changes such as downstream flooding, erosion, impairment of water quality. Whenever possible, it is attempted to derive benefits for recreation, irrigation, etc. (Tourbier and Westmacott, 1974). Many regulations assume that it is possible to achieve these objectives by means of simple rules based on "zero runoff increase" above pre-development levels, applied for design storms with one or several recurrence intervals. Since the "pre-development runoff" is difficult to define, and without adequate measurements may vary considerably with the modelling techniques (Wisner, Kassem, Cheung, 1979), some jurisdictions have preferred to recommend a fixed post-development discharge rate. Examples of such criteria which seem to vary from one jurisdiction to the other without obvious reasons, are given in Table 1 (Lager and Smith, 1974).

Replacement of the real objectives by simplified "surrogate" objectives is very frequently encountered in the regulatory process of various water resources activities. Typical examples are the floodline delineation for the "one in hundred year flow", the drainage design for say "5 year storms" or the requirement of water quality management to achieve say 5 mg/1 dissolved oxygen. Implementation of simplified criteria of course facilitates the regulatory process and leads to relatively routine design.

A case by case analysis based on specific conditions of each site is, on the other hand, advocated by those who would like to optimize the selected alternative in terms of tangible and intangible benefits. This approach is at present possible in Ontario and in most Canadian provinces, where there are no stringent runoff control regulations similar to those described in Table 1. An extensive research program on Storm Water Management was conducted between 1973-1978 under provision of the Canada-Ontario Agreement on Great Lakes Water Quality. As a result, a a general document on policies for urban drainage management was drafted by a committee including representatives from various Ontario agencies. The draft document which is presently circulated for review presents *principles* and *general requirements* for master drainage plans, pollution control strategies, evaluation of hydrologic changes, implementation of dual drainage system, erosion control, etc., but does not indicate specific rules similar to those described in Table 1.

Under those conditions, Storm Water Management and Runoff Control Measures are implemented according to the experience and needs of Municipalities and Conservation Authorities.* Some municipalities have consequently adopted the "zero runoff increase principle" while others favor a more flexible approach.

Based on the experience with several pilot projects, the Town of Markham has developed runoff control criteria based on site-specific analysis. The advantages and disadvantages of this approach which may be of interest for comparison with the experience in the application of simpler regulatory measures, will be discussed by means of examples in the next sections. The first writer was responsible for the philosophy of the criteria and developed some of the technical solutions carried on in several pilot projects. The Town Engineers had the difficult task of the implementation of the criteria and storm water management facilities. The actual design was the result of a cooperative effort of many professionals from various consulting firms and reviewing agencies. Their contribution is gratefully acknowledged.

II. DEVELOPMENT OF THE MARKHAM SWM CRITERIA

The Town of Markham, located at the North East of Metropolitan Toronto, is an example of a fast developing community with various potential problems caused by runoff increase. Storm water from some of the new developments is discharged southwards to Scarborough where some areas have experienced severe flooding and others are drained by very large channels designed for the 1/25 year storm. Other new developments, in the northern part of Exhibition Creek, for example, discharge in existing channels with culverts built many years ago with a lower level of protection than presently required by the Metropolitan Toronto Regional Conservation Authority. Other developments will discharge in scenic streams and ponds such as Togood Pond and Bruce Creek.

The Municipal Council and the Town Engineers realized at the early stage of development that traditional drainage projects submitted by some developers will result in environmental problems and high costs including payments for increases in capacity of storm sewers in the neighbouring municipality.

Recent experience of other municipalities in Metro Toronto which have undergone intensive development several years earlier, showed that for a traditional drainage even with an increase of design frequency it is not possible to avoid flooding. Two situations which occurred not

*In Ontario the Conservation Authorities are organized on a watershed basis between other responsibilities are also in charge with flood plain management.

too far from the Markham boundaries were of particular interest. The first was the flooding of a group of condominiums caused partly by a discharge from the major system. The second was the flooding and damage to basements in an expensive residential area caused by storm sewer surcharge during a very severe storm. (The foundation drains in the area as in most Metro Toronto are in general connected to the sewers which results in case of surcharge in back up flooding and uplifts effects.) These situations generated interest in improved major drainage design and inlet controls.

After a review of the state of the art, lectures and a study tour of Council Members, Staff and Developers in Montgomery County, it was decided to implement Storm Water Management on all new developments. It was considered, however, that this should be done in a flexible, site tailored way rather than by stringent regulations.

The preliminary Markham Criteria for Storm Water Management (1978) follow a systems approach. The general objectives of the Storm Water Management projects are to economically achieve safety against flooding and health hazards, minimization of environmental impacts and to derive recreational or aesthetic benefits. In order to achieve these goals criteria developed with the assistance of the first writer require that all SWM studies be conducted in two phases.

The phase I study has to define prior to any design the specific problems of the drainage system and especially the restrictions related to (i) erosion control, (ii) flood control, (iii) inadequate outlet capacity, and (iv) impairment in receiving water bodies. The first phase study has to examine several drainage alternatives, including a traditional one and various levels of runoff control. It has to *"assess each alternative on the basis of economics, environmental and ecological impacts, compatibility with general development plan and evolve preliminary cost estimates for comparison."*

As a result of the Markham criteria, some SWM studies considered not only "zero runoff increase" but other types of control as well. It was found that in some situations post-development flow should be smaller than the pre-development flow. This concept of "over control" may be considered if there is no outlet capacity or if there is already downstream flooding under existing conditions. In other projects, post-development flows are reduced as compared to traditional drainage, but were maintained larger than the pre-development flow. The flow increase for this "partial control" can be dictated by economic considerations and local impacts. It is also possible, as in the case study described in the following paragraph, to have "partial control" for say the 5 year storm and "over control" for the 1/25 year storm. It is suggested to adopt the name of "selective control" for this approach which is different from the "generalized" zero-runoff increase considered by some regulations (Figure 1).

After approval of the "Phase I-SWM study" by the municipality and the various regulatory agencies, developers have to submit a "Phase II-SWM study" which has *"to present the design and operation details of a well conceived Storm Water Management scheme that defines the drainage pattern for the watershed."*

Both the first and second stage will consider protection against basement flooding for flows with return periods from 2 years (design condition for pipes) to 25 and if technically feasible for 100 years (design condition for the major system). In particular, *if foundation tiles are connected to storm sewers, surcharge conditions for intense storms have to be checked against basement elevations.*

According to the Markham criteria, hydrologic modelling should be carried on based on a hierarchical approach, and is in general more sophisticated than required by the regulations reviewed by Debo (1974) or Poertner (1974). It is also required that calculation of storage and development of hydrographs "should be carried on by an experienced hydrologist". This accounts for the present state of the art on urban hydrology and the concept that the experience of the modeler is more important than the features of the model.

The Rational Method is accepted for preliminary pipe design. For predevelopment flows and major system analysis, consultants may select a hydrograph model such as HYMO, ILLUDAS or SWMM but have to justify it according to their experience and the nature of the specific problem. All the data and basic parameters such as soils infiltration rates, and slopes should be given in an appendix of the SWM study.

Modelling in stage I is done with design storms which should cover a frequency range from 1/2 year to 1/100 year. For preliminary studies it is possible to use the Chicago storm profile while the 24 hours storm or S.C.S. is used for rural conditions.

In stage II, *"when the watershed exceeds say 40 ha, the minor system should be checked by detailed computation for ensuring proper operation control, maximizing the use of in-system storage and the underground storage. Such simulation would eventually permit control of any surcharge that would exist in the pipe system due to outflow constraints. Computer models such as SWM with the WRE TRANSPORT model can be used for such modelling. It is further understood that the siting of the building will be such as not to allow surcharge from the sewer to affect the basement."*

Another important provision for phase II regards the meteorological input. *"Actual operation of the designed system has to be analyzed and it would be beneficial to simulate one or two critical historical storm events, in terms of outflow rates and outflow volumes prior to finalizing the drainage scheme. This would be in addition to simulating the system for the design events".*

The criteria do also indicate the need for a landscaping project for all surface storage units.

The application of the criteria including the analysis of the major drainage system and the acceptability of "selective control" are illustrated by an example of an alternative adopted in several projects.

III. PARK STORAGE FOR THE MAJOR SYSTEM

Routing of overland flows on streets for major storms is a physical reality which was not considered until recently. The "dual drainage" concept apparently described for the first time in the Denver Drainage Manual (Wright, McLaughlin, 1969) requires appropriate street grading, analysis of street flow elevations and consideration of street outflows. In several recent Markham projects the access to storm sewers flows exceeding the capacity of pipes within acceptable surcharge is limited by constrictions in the catchbasins or "inlet controls".* Excess street flows are controlled using storage in depressed areas in the parks. Street grading is designed to direct the overland flow to low points located at the walkways to parks. Since "inlet controls" are usually designed for 5 year storms, overflow in the parks occurs rarely and maintenance problems are reduced as compared to the "dry ponds" used, for example, in Maryland. *Parks and parkettes have to be strategically located at the early stages of planning; one of them being relatively close to the outlet.*

Outflows from parks are controlled to 0.150 m^3/s or less, and consequently during any major storm the outflow is practically equal to the pipe flow. In some projects, such as North East Markham, the 5 year pipe flow, significantly larger than the pre-development 5 year flow and somewhat less than the 25 year post-development flow was considered acceptable after an analysis of downstream conditions. In other situations such as West Riseborough, the post-development flow was reduced by means of underground storage by means of an oversized "superpipe". The operation of this "dual storage" system is described in Figures 2 and 3.

The depression in the park area must meet the storage requirements for overland flow from a 100 year storm. Parks are landscaped accordingly. Eventual sport facilities may be located at an intermediate level and their flooding frequency reduced correspondingly. Parks were also used in some projects to store overflows from the pipe system if the surcharge level exceeds the prescribed elevation (Wisner and Kassem, 1979).

In West Riseborough, the outflow from the pipe system resulted from a trade-off with the downstream municipality, the Borough of Scarborough. Markham was allowed some increase of the 1/2 and 1/5 years flows above the pre-development level which led to a reduction of the cost of the superpipe. In exchange, 1/25 year flows are reduced to less than pre-development level (over-control) which alleviates Scarborough flooding problems, which are mainly caused by the lack of capacity of the major system.

Analysis of several projects indicates that park storage requirements for the 1/100 year overland flows, assuming a mean depth of 3 ft, can be met with approximately 3% of the area of a development. Since the area dedicated for parks represents approximately 5%, it was found that over-control of large flows is possible without other additional land dedication and expenditures but landscaping and pipe connections.

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*A study for the sizing of inlet controls was carried on by Dr. R. Townsend and the first author in the hydraulic laboratory of the University of Ottawa. (Townsend, Wisner and Moss, 1979).

IV. ON SITE VS. WATERSHED PLANNING OF SWM FACILITIES

Location of park storage or superpipes within each development is difficult especially if some properties are relatively small. It was also recognized that in order to derive the maximum hydrologic and environmental benefits, it is preferable to concentrate and strategically locate a few storage units rather then implement many "diffuse" facilities. The best approach, therefore, would be Storm Water Management on a watershed basis. This, however, may result in significant efforts for data collection and modelling. Alternatives would have to consider the interests of a large number of landowners and eventually to meet the approvals of several jurisdictions occupying different parts of the watershed. Most of the developments were already under way at the time when SWM was implemented and studies had to be carried on with time and budget constraints.

Although this was not included in the drainage criteria, the Engineering Department has encouraged several studies on a community basis for larger areas, representing a significant portion of the watershed. This is a compromise alternative in which the hydrology and environmental problems of the entire watershed are considered, but only in a cursory way. Storm Water Management is, however, studied in detail for a much larger area than a single development. An example is the study for developments on the Exhibition Creek in the Rouge River Watershed (MacLaren, 1977). Detailed Storm Water Management options were studied for properties involving several owners. The study examined water quality, flooding and erosion in the downstream areas and compared several alternatives including:

1. traditional drainage without storage and with channelization of a creek,
2. zero runoff increase with diffuse storage (control on each property),
3. concentrated storage using two offsite ponds with recreational benefits,
4. combination of alternatives 2 and 3,
5. same as 4 including channelization of a creek in development.

The last alternative recommended the construction of two Storm Water Management ponds upstream the area under immediate development. One of these ponds, lake A, would be built on a small creek simultaneously with the development. The second, lake B, would reclaim a gravel pit and will also be required when development will be expanded in the upper watershed. The two wet ponds will be located in a park setting and will be a refuge for wild fowl.

The alternative represented again a trade-off solution in which the developers would accept to support off-site storage. In exchange the diversion and channelization of the small creek in the development made possible an increased acreage available for development. Floodplain management regulations in Ontario oppose any channelization for watersheds larger than 1/2 square mile. The area considered was slightly larger than this limit. The study considered, however, that the creation of ponds would represent an environmental amenity which may compensate for this modification, and this viewpoint was accepted by the Metropolitan Toronto Regional Conservation Authority.

Specialized assessments by hydrologists, biologists, hydrogeologists were incorporated in a matrix comparison of the various alternatives, which also included maintenance, effects on land development, etc. The selective control principle was again applied. Zero runoff increase in the development was considered only for floods with a return frequency of more than 25 years. Some increase of the 1 in 5 years and 1 in 10 years floods was found to be permissible accounting for the downstream conditions.

Another example of attempting to derive recreational benefits from a Storm Water Management project, is a development around the Togood Reservoir created by an old mill. A preliminary study of water quality changes by means of the STORM model indicated that non-controlled discharges may impair the water quality in the impoundment. Diversion by means of an interceptor of some overflows and sediment traps were considered. Development in a band around the lake will be controlled and the scenic valley downstream of the pond will be protected. The cost of rehabilitation of the dam and its surelevation in order to extend the water surface area will be partly absorbed by the development. Partial control for more frequent floods instead of zero runoff increase is considered acceptable and has to be justified on a case by case basis (MacLaren, 1978).

V. ADVANTAGES AND DISADVANTAGES OF SITE TAILORED CRITERIA

These examples and several other projects represent a limited experience of only 3 years. The advantages and disadvantages of the Criteria will be discussed from the viewpoints of the various parties involved.

The analysis of multi-objective studies, involving several alternatives, non-tangible considerations, sophisticated models represented for the municipal staff a significant additional effort as compared to traditional drainage schemes. It is also probable that simple regulations for zero runoff increase such as applied in Maryland would have also been easier to implement. The multi-objective interdisciplinary approach was facilitated by the fact that the Municipality had a relatively small staff which made frequent communications between engineering, planning and recreation department much easier than in large organizations. The interest in Storm Water Management was promoted by the fact that on the West Riseborough project the implementation of SWM measures permitted an early start of construction and also significant savings including payments to other municipalities for accommodating flows were possible. On other projects, staff and council were interested in creating increased recreational amenities.

The application of sophisticated modelling does not seem to create particular problems. Checking by the Municipality included only model assumptions inputs and results which have to be presented clearly in each report. Detailed reviews of computations were done by the Ministry of Environment or ad hoc consultants. The Municipality keeps itself up-to-date with modelling developments by participating in the IMPSWM project, a cooperative research program organized by the University of Ottawa. Most of its consultants are in the same program which will eventually result in some level of standardization in modelling.

Probably the most difficult aspect for the Town Engineers was the selection of alternatives based on trade-offs with multiple objectives and development of acceptable cost-sharing procedures for off-site storage. To a large extent, this was possible by involving the elected officials in the decision making. Council members, however, became interested in the challenge of participating in the analysis of Storm Water Management alternatives and developed a very good understanding of basic SWM principles. The field trip to Maryland for the inspection of various facilities and lectures had an important role in educating the municipality and bridging the initial communication gaps between various disciplines as well as between laymen and specialists. A firm support to the Markham engineers in their endeavours to implement SWM was received from the various agencies including the Conservation Authority, the Ontario Ministry of Natural Resources and the Ontario Ministry of Environment.

Developers reacted in terms of the effects on the cost of SWMM measures for their particular projects. There is generally no rule, unfortunately, concerning whether the implementation of SWM will or will not be less costly than a traditional design. In the first example described in section III, it was obvious that the use of park storage led to a more economic alternative than the building of large downstream culverts. In the second one, the traditional project would have been more economic <u>if</u> downstream potential damages are not considered. It is felt that site specific criteria based on a watershed analysis of constraints such as water quality effects and downstream flooding or some trade-offs between environmental components are more difficult to accept than a generalized regulation. The implementation of site tailored criteria requires training for consultants. The IMPSWM program will therefore organize courses on multiobjective design of runoff control facilities.

It seems, however, that more research is required on the economics of runoff control facilities, cost-sharing and matrix methods as tools in decision making.

Another important concern from the developers viewpoint was the increased duration of SWM studies as compared to traditional pipe sizing. This, of course, related to the experience of consultants. Larger consulting firms with hydrologists on their staff produced reports in a reasonably short time. Some of the smaller ones, previously involved with traditional design hired specialized staff.

The Town experience shows that implementation of modelling has not increased significantly the duration of the analysis and approval process. Some delays result from the need to examine and negotiate a wider range of alternatives than in conventional projects.

FINAL REMARKS

The Markham experience suggests that the implementation of site tailored criteria and alternative selection on the basis of trade-offs between various objectives is feasible and may lead to advantageous and innovative runoff control alternatives. These alternatives comprise traditional drainage, "generalized zero runoff increase" and also "partial control", "over-control" and "selective control". Zero runoff increase is considered as a means to achieve environmental and flood control goals but it is recognized that at the present state of the art, there is no justification for a very rigid application and some flexibility is possible. This approach required sometimes lengthier reviews and discussions but it was found that various regulatory agencies and most developers were in agreement with the proposed alternatives. *Support, involvement and understanding of the issues from the political decision makers is a key factor in the site tailored criteria.* Hydrologic analysis by up-to-date methods is also considered essential for the analysis of the simultaneous operation of the major and convenience system. The present process can be improved and a recent drainage manual board on the same philosophy and recently adopted in Oakville, another municipality in Southern Ontario, (Brodie and Wisner, 1979) will eventually be adopted to facilitate the application of the site tailored runoff control criteria.

More research and an analysis of various experiences is, however, required before drawing a conclusion regarding the choice between the case by case analysis and the standard simplified regulatory approach. The role of modelling in the development of national runoff criteria and the standardization of models for SWM projects are studied in the IMPSWM project of the University of Ottawa.

ACKNOWLEDGEMENT

Projects described in sections 3 and 4 were conducted by James F. MacLaren Limited and Fred Schaeffer and Associates. Several engineers from both firms contributed to the specific hydrologic analyses and detailed projects. Mr. A.R. Steedman, Mr. Jankovic, and Mr. B. Reid deserve special credit for their contributions. Landscaping of all Storm Water Management facilities described in the paper was done by Mr. D. Farb and Mr. L. Thompson, Toronto. Suggestions from Mr. W. Warwick and Mr. T. McMullen from the Borough of Scarborough and comments from Mr. C. Mather and J. Maletich (MTRCA), R. Chin (MOE), M. Lewis (MNR) and many others led to the development and improvements of the described concepts and are gratefully acknowledged.

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TABLE 1

EXAMPLES OF RUNOFF CONTROL LEGISLATIVE PROGRAMS
(after Lager and Smith, 1974)

Location	Description
Denver Urban Renewal Authority	Release rates for plazas limited to 1 in/hour during the 10-year storm.
Nepperville, Illinois	Maximum release rate 0.15 in/hour.
Joliet, Illinois	Release rate to exceed runoff from a 2-year storm with a runoff coefficient 0.3.
Albuquerque Metropolitan Arroyo Flood Control Authority	Rate of runoff not to exceed natural rate of runoff.
Metropolitan Sanitary District of Greater Chicago	Release rate determined by the rational method with a runoff coefficient of 0.15.

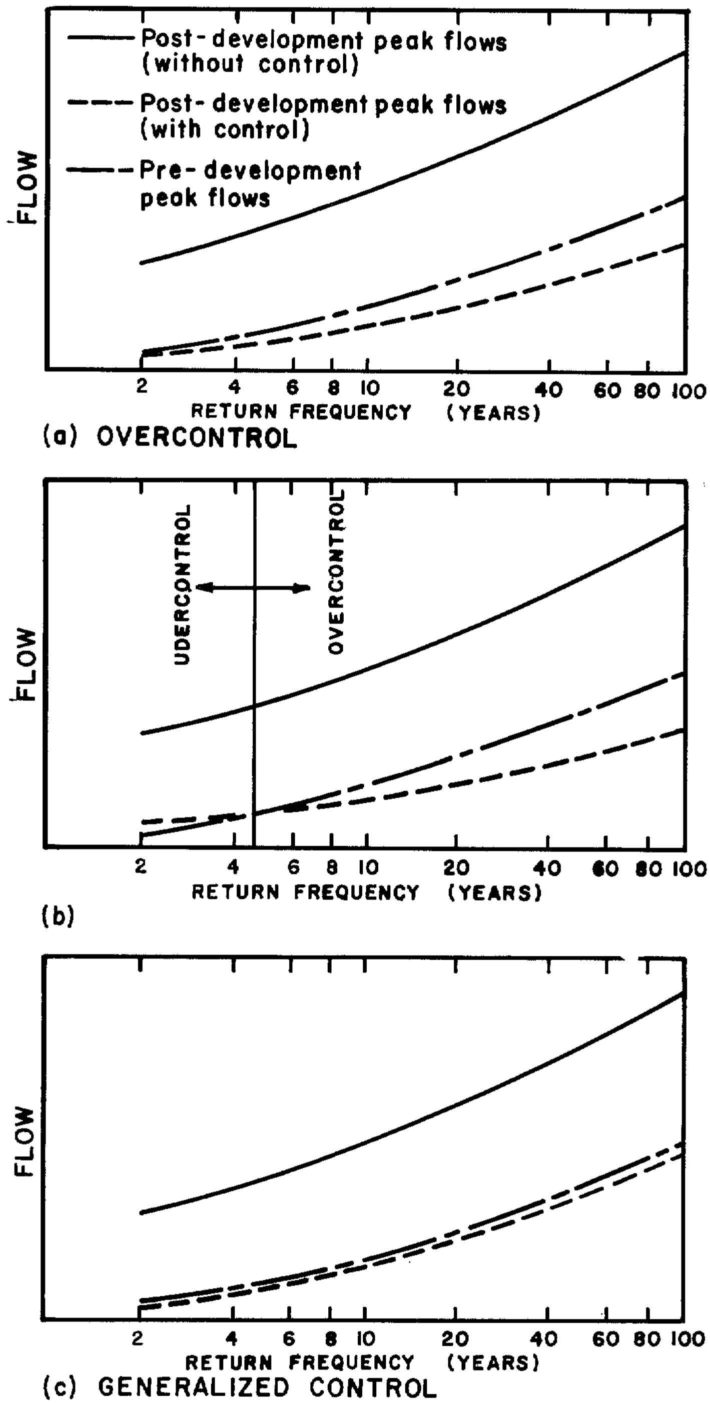


Figure 1 Policies for Runoff Control

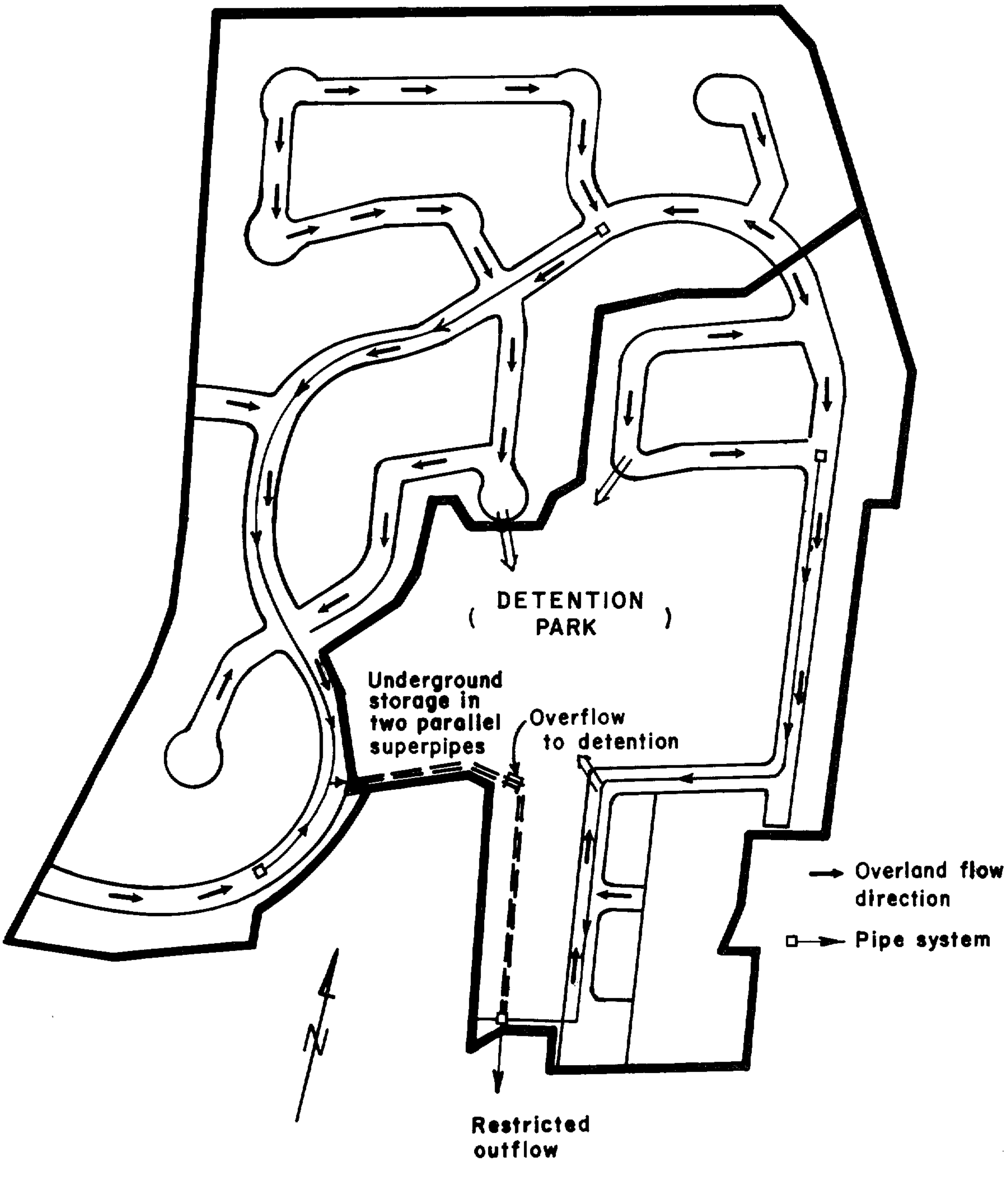


Figure 2 Typical Subdivision with Dual Storage System

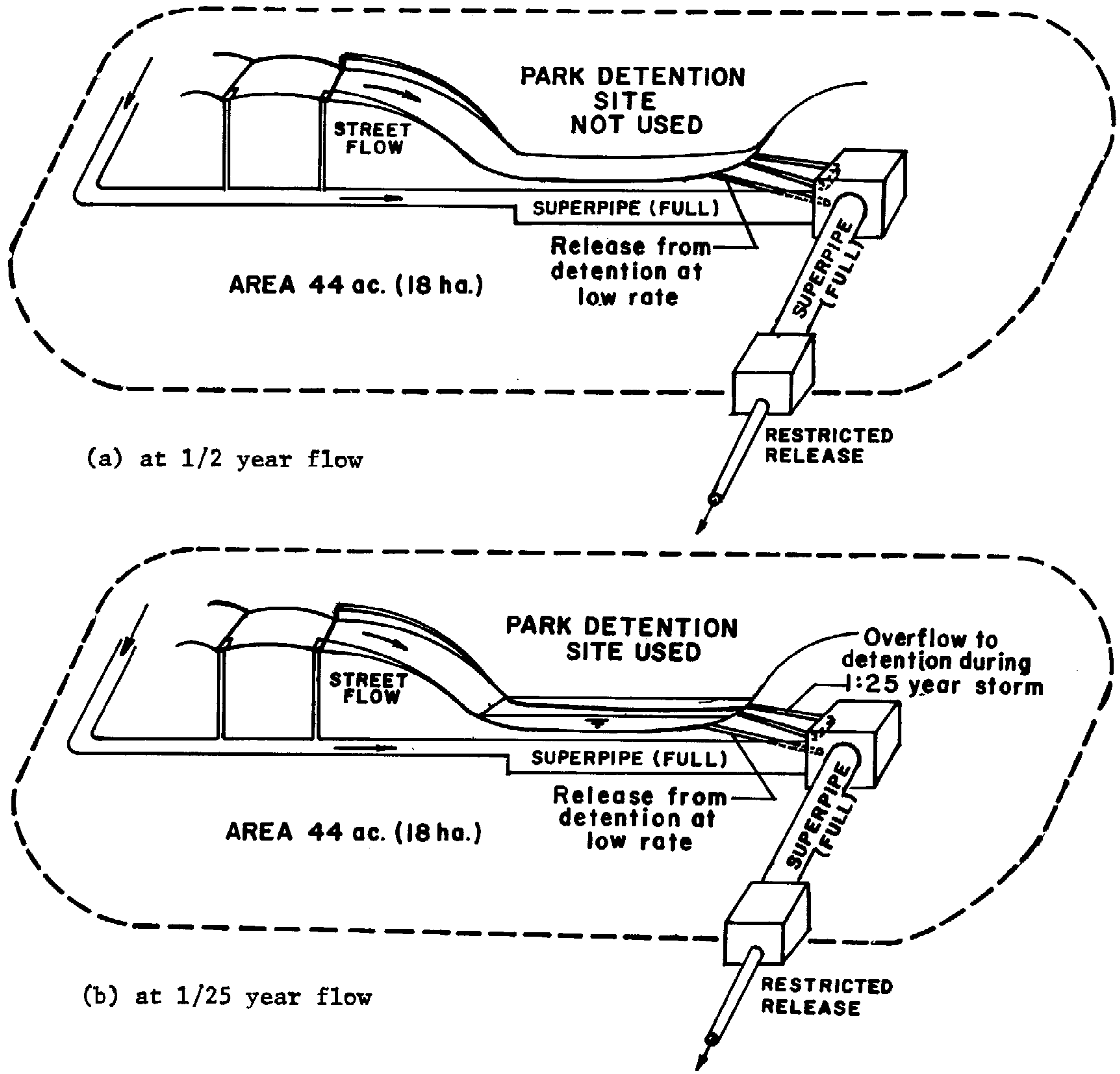


Figure 3a Operation of Dual Storage

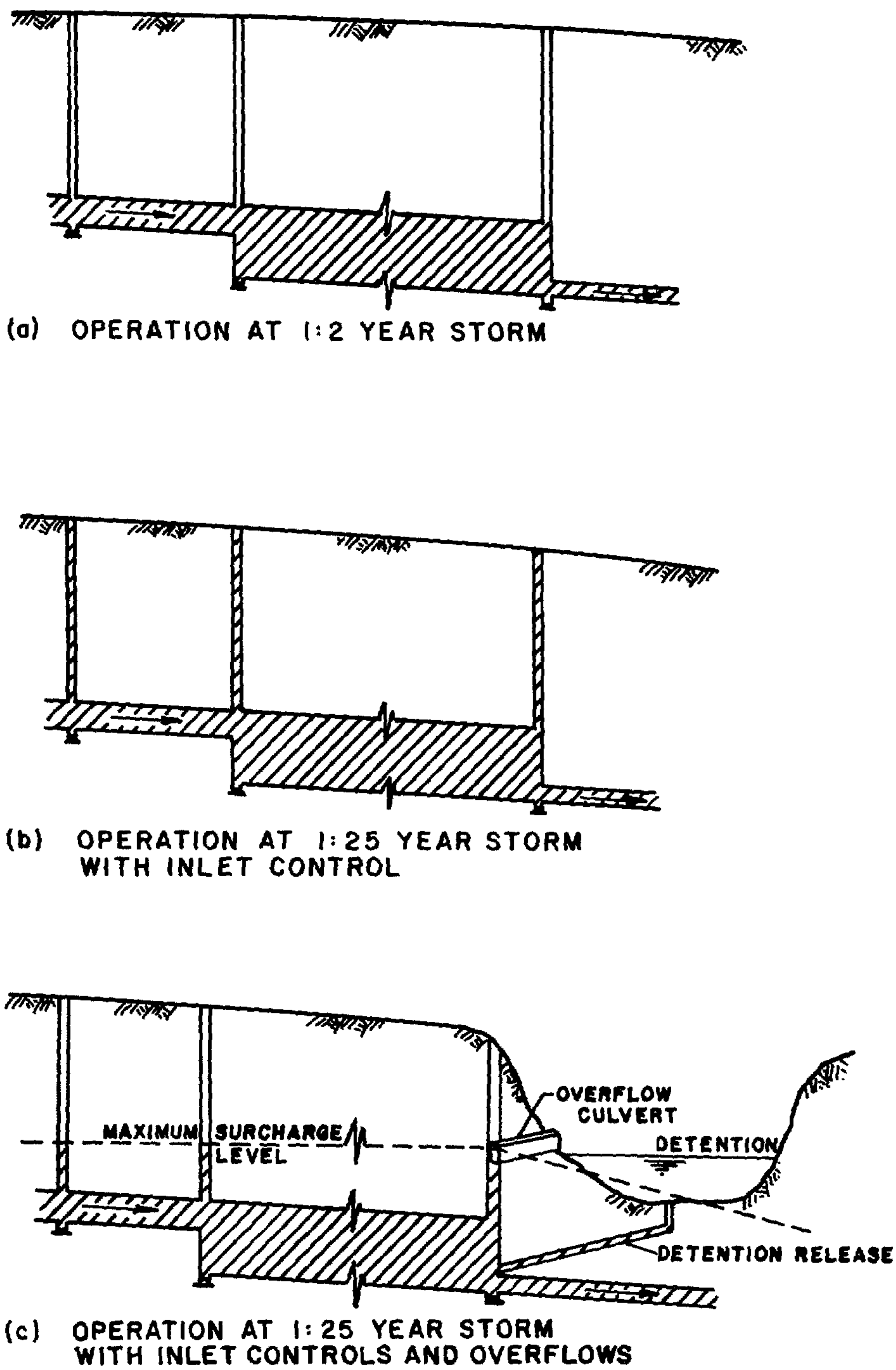


Figure 3b Operation of Convenience System Storage for Different Storm Frequencies

Agricultural management practices are responsible for the beauty of the Brandywine Valley which has attracted noted painters like Andrew Wyeth.

15

PUBLIC VALUES AND A RIVER - THE BRANDYWINE STORY

WILLIAM SELLERS

The Brandywine Conservancy, Chadds Ford, PA

For 150 years, Wilmington and its smaller Pennsylvania neighbor to the north, West Chester, have been way stations for a succession of important American artists who have explored the natural, social, and psychological environment of the unique valley of Brandywine Creek. The Brandywine River Museum in Chadds Ford is dedicated to the preservation of both the art of this area and the natural and cultural environment which has been its inspiration.

Beginning in the early 19th century with landscape painters, a succession of great American artists in the realist tradition have made this area their temporary or permanent home: Bass Otis and Felix O. Darley were very early. Howard Pyle, the great American illustrator, through his schools in Wilmington and Chadds Ford, had a profound effect on the development of many great American illustrators of the late 19th and 20th centuries: Maxfield Parrish, Frank Schoonover, Jessie Wilcox Smith, Harvey Dunn, and N. C. Wyeth to name just a few. N. C. Wyeth, who settled in Chadds Ford, was the father, father-in-law and grandfather of several of today's best known artists of the Brandywine, Andrew, his son James, and Andrew's brothers-in-law, John McCoy and Peter Hurd. The Pyle School of Illustrators, the West Chester artists, George Cope and Horace Pippin, and today's artists have reflected two elements of their environment: (1) their love for the landscape, its constituent elements, and its people and (2) a private, individualistic, probing of personal emotions and truth in their subject matter. This last is but one example of the impact of the Society of Friends on the total environment of this area.

The pervasiveness of an artistic tradition for over 150 years is but one example of the continuity of certain values and cultural traditions in the Brandywine Valley. Until the 1960's, the Brandywine was, in the main, a pastoral agricultural community, strongly dominated by old Quaker families whose individualism, thrift, respect for consensus decision-making and commitment to education and diligent research had established a special imprint on public and private institutions in the area. Although principally an agricultural valley, industrial nodes and small cities in the upper Brandywine along Route 30 and the county seat of West Chester developed as population

Flush flows of the Brandywine River
caused by a spring thaw.

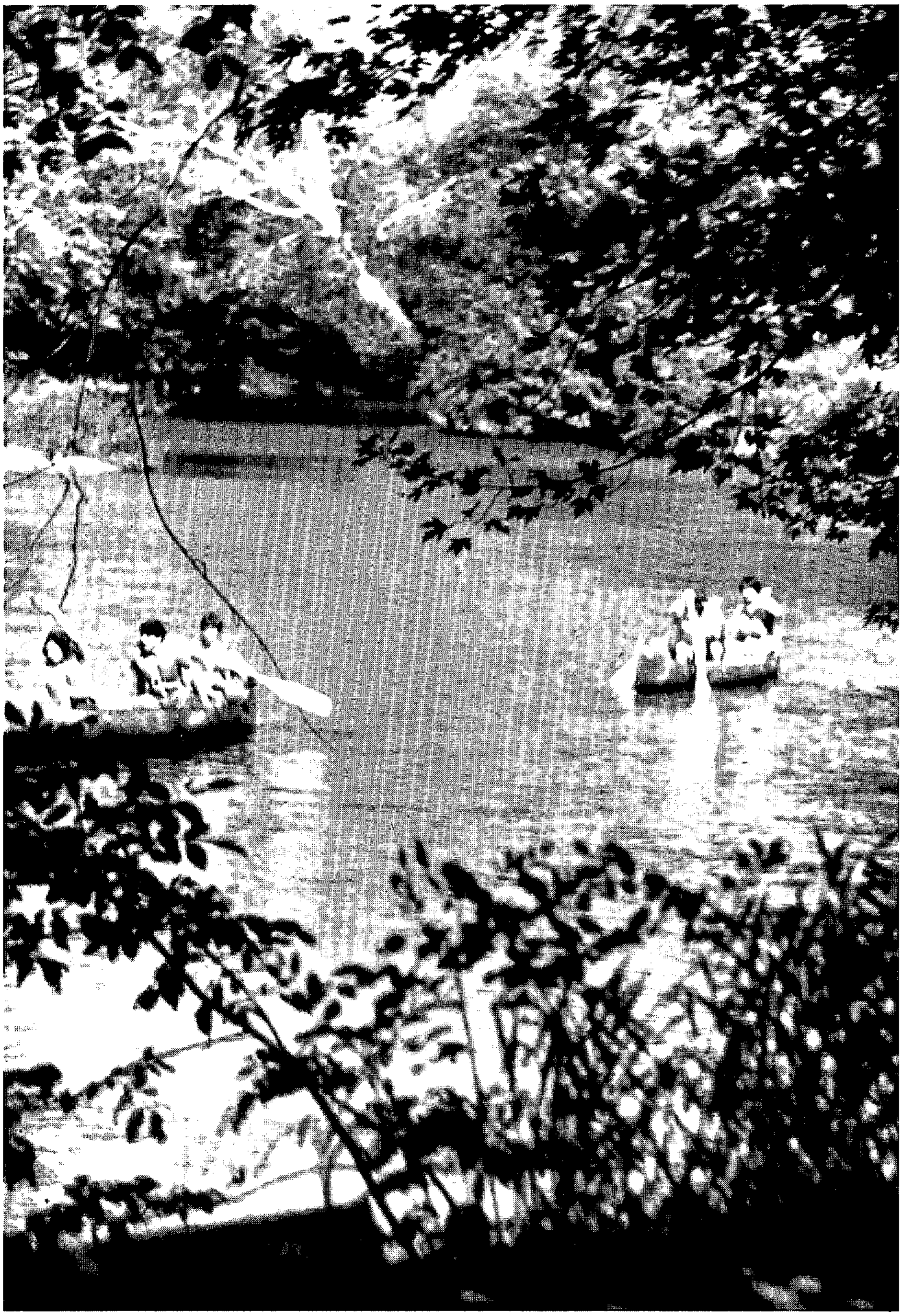
centers between 1830 and 1940. In the mid-1940's, it had become obvious to many Valley residents that industrial and domestic sewage was severely polluting the Brandywine. In 1945, one of the first private watershed associations in the country was formed to work with the cities and industries to clean up the Brandywine. This organization, the Brandywine Valley Association, continues to this day as an institution providing public education and public forums for discussion of many specific problems in the Brandywine.

The Brandywine Conservancy was founded in 1967 when it became apparent that land development was posing a new threat to the Brandywine Valley. Stormwater runoff was increasing flood events and adding pollutants to the stream. Historic sites were threatened with demolition by proposed highway projects and by development generally, as were many of the most important natural areas. The archaic zoning and subdivision laws of the sparsely populated and underfunded local governments provided little protection to the cherished cultural symbols of the Valley.

When Chadds Ford, the home of Andrew Wyeth and the center of artistic endeavors in the Brandywine for eighty years, was threatened by all of these problems, the residents of the lower Brandywine coalesced in the formation of an organization to deal with the new land use and water resource issues facing the Valley. They recognized that development in some form was inevitable, but they did not want the Brandywine Creek and the Valley to be despoiled in the same manner as most stream valleys of the northeast which had undergone rapid urban development. The Tri-County (New Castle, Delaware and Chester and Delaware Counties in Pennsylvania) Conservancy of the Brandywine, now the Brandywine Conservancy, was formed to meet these challenges.

Community action by aroused residents and volunteer staff won many battles in the late 60's and early 70's. Power line projects were modified, three devasting highway proposals were eliminated, plans for a new international airport abandoned, and the industrial development of the Chadds Ford floodplain was preempted by acquisition. One of these acquisitions was an historic grain mill which has been restored as the Brandywine River Museum, a showcase for the Brandywine tradition of art and other historical artifacts of the area, and a center of the cultural community.

By the early 1970's, the Conservancy's members realized that a full-time professional staff and the



Canoeing, hiking, nature study and other outdoor
recreation activities center around the Brandywine River.

assistance of the major research institutions of the area would be needed to develop long range programs which would insure the highest level of environmental quality for the Valley. Dr. Ann Louise Strong and other environmental lawyers from the University of Pennsylvania were hired to develop a handbook of land use and water resource protection ordinances for Pennsylvania local governments. Originally developed to assist one township, the Environmental Management Handbook has been the building block for a major subscription program providing local governments with ordinances and planning assistance which incorporate the latest legal and environmental research. Over 50 local and county governments, and state, federal, and private agencies now subscribe to the service. The program has grown through the promotion efforts of staff, Conservancy members who live throughout the region, and those who have used the Handbook.

Recognizing the importance of private land use decision-making, a Wilmington land use lawyer and member of the Conservancy agreed to assist in the development of a conservation easement program which would allow private landowners to voluntarily restrict the development and modification of those areas of their property which heavily impact water resources: the flood plains, steep slopes, ground water recharge areas, wetlands, et.al. The conservation easement used in conjunction with a facade easement also has been an important tool in insuring the long-term integrity of historic sites. Over the past ten years, conservation easements over 4,000 acres have been donated to the Conservancy by landowners in the area. With a full-time professional staff, we expect to add several thousand more every year. The costs of staff are shared by the donor landowners and the Conservancy. Once again, the program is promoted by a combination of staff, members, and former donors.

Before leaving the land use area, I believe that several things are worth mentioning. First of all, our organization firmly believes that one cannot preserve water quality and flows without controlling the use of land. We do not believe that open space is just an amenity, it is a necessity. Nowhere in the United States have we ever been able to have truly high environmental quality and dense urban development. No river or stream can absorb all of the pollutants from point and non-point sources. None can absorb unrestrained stormwater runoff without flooding, and few surface water supplies are dependable in quality or quantity when their headwaters undergo typical urban development. It is clear to us that extensive open land buffers are essential to absorb and treat pollutants, to control flooding, and to renew precious ground water supplies.

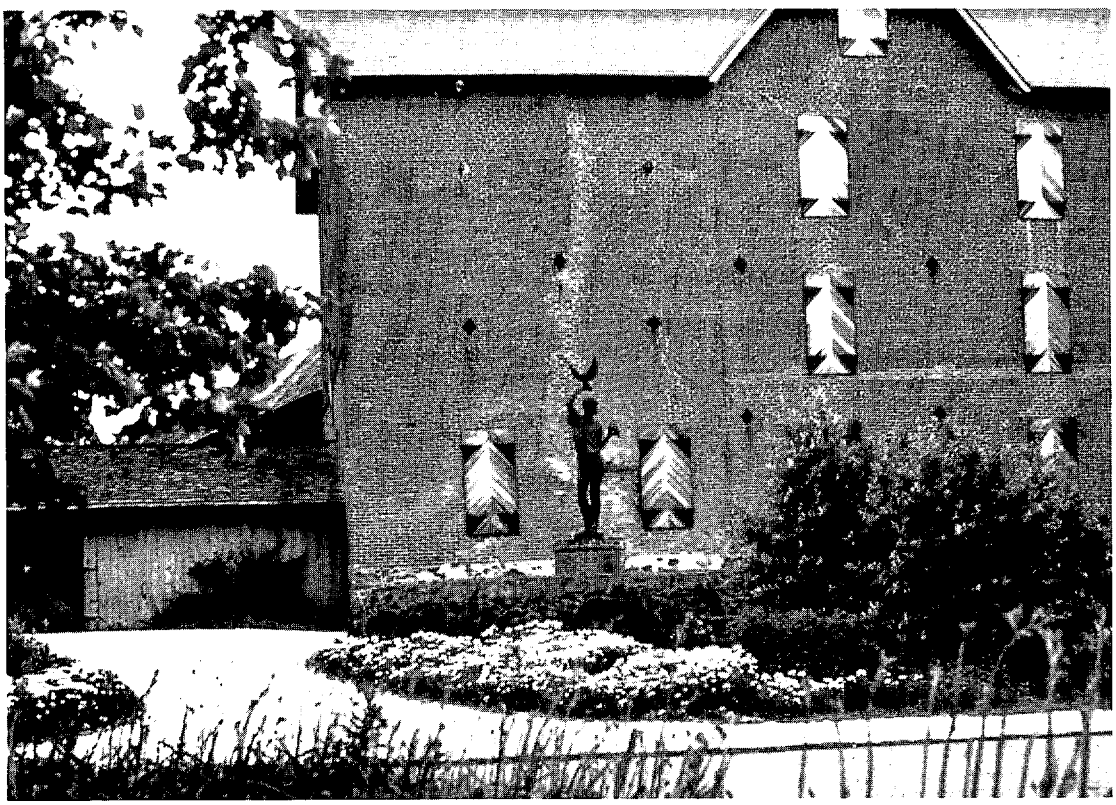
Trout fishing in the Brandywine River is
aided by a state stocking program.

Secondly, the promotion of this concept and, indeed, the formulation of many of the technical approaches have been much easier for us because of the pioneering work of Professor Ian McHarg and his staff at the University of Pennsylvania. The publication and distribution of McHarg's Design with Nature has had a major impact on this region.

The third major program area of the Conservancy has been water resources management. A three year, half million dollar study of the Brandywine (1972-74) provided us with exceptional understanding of the hydrologic cycle of the stream and provided the data necessary for the formation and calibration of predictive water quality and stormwater management models. With this information we have become convinced of the need for land application of sewage, the need to control stormwater where it falls and to encourage its recharge to the ground water table, and the need to increase our efforts to provide land buffer areas. Conventional sewage treatment plants have not worked and non-point sources are major contributors to water quality degradation. For the past two years, the Conservancy staff has served as environmental consultants to one major sewage facilities planning study of the headwaters area of the Brandywine and several smaller planning projects. If the plans proceed as anticipated, land application of treated wastewater will become a dominant treatment mode and a major force in the preservation of open space and agricultural land.

For the past five years, local governments in southeastern Pennsylvania have become increasingly concerned about erosion and sedimentation control and the more far-reaching problems of stormwater management. In 1973, Dr. Anne Louise Strong provided us with one of the first model erosion and sedimentation control ordinances developed specifically for Pennsylvania. For the past two years, Conservancy staff has been revising this model to embrace broader concerns of ground water recharge, stormwater quality, and protection of critical slopes. During the course of the work, the Pennsylvania Department of Environmental Resources contracted with the Conservancy to review the state-of-the-art of the stormwater management regulations and practices of local governments in Pennsylvania. This study will be completed shortly. Pennsylvania DER will publish the entire report, but we will be publishing an abbreviated version of the report along with our new stormwater management ordinance in the very near future.

From our recent study and numerous discussions with local officials in southeastern Pennsylvania, certain themes have been recurrent. First, most officials and professionals believe that runoff in excess of natural conditions should be controlled on the site. Secondly,



The Brandywine River Museum is a converted mill
that now houses a permanent exhibit of the Brandywine School
of Painting and the office of the Brandywine Conservancy.

all of the costs of facilities, review of plans, review of construction and such should be paid by the developer, not the community. Third, more attention needs to be given in planning and zoning to the stormwater problem potential of various soils and geological structures, e.g., concentration of stormwater in limestone areas can cause sinkholes and other problems. Fourth, good stormwater management practices can reduce expenditures of property owners, developers, and the community. Finally, well-planned stormwater facilities can provide other benefits to a community in the form of fire control ponds, recreational sites, and wildlife habitats.

In many sections of the country, people would say that the ideas which I have expressed are anti-development. The fact is that in most of the Brandywine Valley, people are neither a priori for nor against development. We are strong believers in individual responsibility and respect for one's neighbors. An individual who chooses to develop his land should be responsible for all of the costs which attend his choice and he should not expect his neighbors to pay for his decisions through inconveniences, damages, or increased taxes for public improvements.

Certainly, some of what I have said has been generalization. We, like you, have had failures as well as successes. I truly believe, however, that if any section of this country is going to successfully develop a comprehensive approach to land development which recognizes the importance of natural beauty and the inherent limitations of our natural, social, and economic environments, it is the Brandywine country - southeastern Pennsylvania and northern Delaware.

16

DRAINAGE RECONSIDERED: THE EVOLVING ROLE OF PUBLIC AGENCIES IN DRAINAGE - NEW CASTLE COUNTY, DELAWARE

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1. INTRODUCTION

Drainage programs are about to enter a new phase. Growing fiscal constraints on communities, concern for water quality, EPA's refusal to fund any more sewer projects with excess capacity, all of these reasons have contributed to a renewed interest in urban runoff in New Castle County. Drainage programs have been reevaluated, and both stormwater management* and sediment and erosion control programs are being developed. The days of storm sewers carrying water to the nearest stream are coming to an end.

Changes made by the EPA may be the result of an awareness that conventional drainage practices change the hydrologic cycle of urban watersheds, increase drainage costs and damages, and create significant engineering, social, and economic problems. In urbanizing areas, the growth in impervious surfaces coupled with effective (but conventional) drainage systems increase both the velocity and magnitude of runoff from a given rainfall. Public policies which try to eliminate excess surface water as quickly as possible after a rainfall have only contributed to overdesigned storm sewers and treatment plants, new drainage problems downstream, and increased drainage costs as basins reach full development.

Water quality problems also resulted from these practices, principally from combined sewer overflows, surface runoff laden with urban wastes, and overflows of infiltrated municipal sewage. Other water quality and supply problems occurred as runoff increased and was discharged from the basin: groundwater levels declined, base flow was reduced, and water shortages became more prevalent. It

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*Drainage commonly refers to the act, process or mode of removing water from a site. Stormwater management has been defined as the application of planning, engineering and construction principles to control the quantity and quality of rain-induced flows.

became more difficult for the stream to assimilate wastes and to provide for other beneficial uses, principally domestic and industrial needs. What is being done about these problems?

1.1 CHANGING PHILOSOPHY

One innovation in stormwater management (i.e. zero runoff; Everhart,1973) is the "natural drainage concept" which emphasizes on the detention or storage of rainfall where it falls. These new practices are expected to reduce drainage and flood protection costs, improve water quality, and augment groundwater supplies. Reducing the liabilities and increasing the assets of urban runoff are the new goals.

There is also an awareness that the institutions of water resource management are not prepared for this new philosophy. Several difficulties are apparent. "Conjunctive planning" needs to be redefined so that water quality management is linked with water quantity planning (supply, drainage, stormwater management, recreation, etc.). The responsibility for collection, storage, and treatment of stormwater now shared by individual property owners and the community as a whole may have to be reevaluated. Lastly, the statutory and case law which support the philosophy and objectives of drainage programs may require a reassessment.

1.2 PURPOSE OF PAPER

New Castle County, Delaware's experience shows how a local government developed a drainage program including the philosophical, technical and legislative underpinnings of the program. As the County responded to environmental needs, it was able to maintain the flexibility to cope with individual land use decisions and, in a continuous manner, evaluate its performace and set new directions. The experience illustrates the need for local governments to balance the creation of hospitable environments in which innovative stormwater management techniques can thrive with the assurance of safety for all its citizens.

2. DEVELOPMENT OF THE BASIC DRAINAGE CODE

New Castle County's Drainage Code was developed in two major phases. A policy statement was first prepared followed by a set of procedures, standards and criteria for implementing them. Efforts were made at the outset to develop a Code that was comprehensive. Subsequently, every objective that was added over the years was followed by new implementation measures. Some objectives, added more recently, raise serious technical questions which are still unanswered. How can the quality of urban runoff be improved? What guidelines and methods should be recommended to recharge groundwater? What standards for runoff volume should be used for design purposes? In addition to these objectives, there is great interest in methods to reduce costs and in alternatives for financing.

2.1 HISTORICAL PERSPECTIVE

The first publicly-owned stormwater management system in New Castle County was built in 1890 when the City of Wilmington began an extensive street construction program including a storm sewer system to drain the newly constructed city roads. With the advent of indoor plumbing, provisions were made to dispose of domestic sewage in this system. The standard practice of the time dictated that these combined sewers discharge into nearby streams. When separate sanitary sewers were built in the early twentieth century, extensive sanitary sewer construction began in northern regions of the County. The only stormwater management program in the area was implemented by the State Highway Department. The standards which were established, however, were for the design of storm sewers, catch basins, and drainage ditches only as they relate to highways. Storm drainage problems were controlled only on a limited basis through the review and approval of new subdivision plans.

For some time, the County successfully avoided serious drainage problems. While the population doubled from 1955-65, development was so well scattered that any increases in runoff were sufficiently reduced off-site. Further masking these effects was a series of dry years lasting from 1954-66. In fact, 1965 was the driest year on record (24.90 inches fell - 57% of normal).

In 1967, the deficiencies in the drainage program became evident. Storms in the winter and spring and, in particular, storms on August 3 (4.0 inches) and August 10 (3.5 inches) which were responsible for 127 major flooding incidents, were major factors in raising the public consciousness. An agricultural drainage network was suddenly found incapable of accommodating flows from an urban area. There were specific instances of undersized bridges, culverts, and pipes (less than one-fourth the necessary capacity in some cases), debris blockages, floodplain encroachments, insufficient allowances for overflow, flat grades, deterioration of swales, and little maintenance of existing channels.

2.2 REORGANIZATION ACT

For a number of years the inadequacy of an official means to cope with stormwater had been a public concern. In 1958, the State Legislature proposed the formation of a County Drainage Board. Seven years later, legislation was passed creating New Castle County's present form of government (9 Del. C., 1965). Under this legislation the County was given authority to establish any program or procedure it deemed necessary to take care of storm drainage problems. The Department of Development and Licensing was empowered to establish "lines and grades" and to administer and enforce "drainage facilities and regulations." The Department of Public Works was required to maintain and operate drainage systems.

In 1967, the Subdivision Code was amended to require the County to "insure adequate provisions for . . . drainage." Two ordinances were subsequently passed: one dealing with streams, drainage ditches, and their floodplains, the other with lines, grades, and drainage in developments (Ord. 67-14, Ord. 67-52). With no practical experience with budget preparation for drainage matters, the Department of Public Works was appropriated $30,000 for the Operating Budget and $150,000 for the Capital Budget.

2.3 PHASE ONE

By October of that year, less than two months after the big storms, the development of a drainage program had accelerated. A study was funded to establish the magnitude of the storm drainage problems, to prepare engineering plans for each drainage basin, to develop cost estimates for alleviating the flooding conditions, and to establish a more extensive storm drainage construction program for the County. The program had to comprehensively deal with drainage, sediment and erosion control, floodplains, stormwater management, and all related rules and regulations.

Afterwards, one recommendation of this study led to the creation of a committee of engineers, developers, Soil Conservation Service representatives, citizens and policy-makers to prepare a statement of objectives, recommendations for legislation, and necessary technical guidelines. The Program was divided into two phases. In Phase 1, a Policy Statement was to be prepared. Phase II would then follow with the development of procedures, standards, and criteria for enforcing the Code. Existing laws in surrounding communities were used as models. Table 1 lists the objectives of the program, and Table 2, the subjects of the policies developed in Phase I.

Table 1

NEW CASTLE COUNTY, DELAWARE
SURFACE AND GROUND WATER DRAINAGE CODE

Phase I: Objectives

1. To protect persons and property from serious harm and significant damage caused by storms of up to 100-year intensity.

2. To insure that each residential, commercial, industrial or public development, home and yard is constructed with adequate drainage.

3. To provide that public facilities and watercourses are designed to require minimal maintenance.

Subsequent to the adoption of Phase I on April 29, 1969, the Operating and Capital Budgets expanded by a factor of fifteen (1967-70). Guided by the engineering study, which inventoried potential projects, New Castle County proceeded to build many of the $11.6 million worth of projects in the inventory.

Table 2

SURFACE AND GROUND WATER DRAINAGE CODE - NEW CASTLE COUNTY, DELAWARE

PHASE I: OUTLINE INDEX OF POLICIES

1. OBJECTIVE

2. POLICY ON WATERCOURSE MAINTENANCE
   - 2.1 Responsibility
   - 2.2 Prohibitions
   - 2.3 Erosion
   - 2.4 Design for Maintenance

3. POLICY ON FLOODPLAIN
   - 3.1 Definition
   - 3.2 Preservation
   - 3.3 Restrictions

4. POLICY ON DEVELOPMENTS - WATERCOURSES
   - 4.1 Definition
   - 4.2 Scope
   - 4.3 Surface Water Collection & Disposition
   - 4.4 Stabilization
   - 4.5 Delayed Run-off
   - 4.6 Storms Exceeding Criteria

5. POLICY ON FLOOD CONTROL STRUCTURES
   - 5.1 Tidal Gates

6. POLICY ON GROUNDWATER

7. POLICY ON GRADING FOR DRAINAGE (LINES & GRADES)
   - 7.1 Yards and Other Surfaces
   - 7.2 Overland Flow
   - 7.3 Floor Elevations
   - 7.4 Slopes

2.4 PHASE TWO

Adoption of the Phase I policy statement (Ordinance #69-17) initiated Phase II, and the Drainage Design Committee was reconvened. At the same time, immediate implementation of Phase I proceeded but without a set of uniform criteria. Having only a legislative mandate to regulate drainage, New Castle County implemented the Code through reviews of techniques proposed by developers. The County was involved in a learning process with each section of the Code until such time as appropriate standards could be developed.

One of the first topics was dictated by Public Law 90-448, the federal flood insurance program. For New Castle County to qualify for the program, it had to adopt "permanent land use and control measures . . . which are consistent with the comprehensive criteria" described in the federal law. In response, the New Drainage Code was amended (Ordinance #71-142, Table 3) as well as the Subdivision Code.

Table 3

CHANGES IN DRAINAGE CODE EFFECTED BY VARIOUS ORDINANCES
(Post Phase I Changes)

Article	Section	Type of Change	Effective Ordinance
III. Floodplains	6-9. Restriction	1. Shifts approval of construction to County Council and stipulates criteria for approval	71-142
		2. Establishes penalties	72-21
		3. Defines methods to delineate	72-30

In the three and one-half years following Phase I, the Committee developed criteria for watercourse maintenance, developments in relation to watercourses, groundwater, and grading for drainage which County Council adopted on March 13, 1972 (Ord. 73-32). Among the more significant features were (1) a surface and groundwater agreement that bound developers and the County to specific performances before any building permits could be issued, (2) requirements for the design, sizing, acquisition, and dedication of on and off-site easements, (3) methods for determining the peak rate of runoff, and (4) provisions for approval of lines and grades (Table 4).

2.4 POST PHASE TWO

During the public debate on 73-32, several amendments to Phase I and additions to Phase II were suggested. These amendments and additions were left to be developed and considered at another time in order not to delay the adoption of Phase II.

New objectives, however, were soon added to the Code (Ord. 74-17), and County Council passed a resolution appointing an ad hoc committee of representatives similar to the earlier Drainage Committee to develop erosion control procedures (Resolution 74-70).

Table 5

NEW CASTLE COUNTY, DELAWARE
SURFACE AND GROUNDWATER DRAINAGE CODE

Post Phase II: Objectives

4. To preserve water quality of the streams and natural watercourses in New Castle County.

5. To minimize sedimentation and erosion.

6. To promote delayed run-off by requiring the use of on-site retention where necessary.

7. To promote the utilization of groundwater recharge techniques where feasible.

As the Sediment and Erosion Control Committee proceeded with its assigned task, the term "stormwater management" frequently crept into the discussions. The Committee recognized that sediment and erosion control is only part of the overall stormwater management picture and that a policy paper should be prepared to identify the components of stormwater management, to recommend procedures, and to establish criteria for the design of detention basins. On June 28, 1977, New Castle County Council adopted by resolution two standards for enforcing the Code: standards for "Stormwater Management" and a "Specifications Guide for Sediment and Erosion Control" (Resolution 77-144). Additonal ordinances have also been passed as the Code has been refined (Table 6).

Table 4
CHANGES IN DRAINAGE CODE EFFECTED BY ORDINANCE 73-72
(Phase II of Drainage Code)

Section		Sub-Section		Type of Change
II.	WATERCOURSES MAINTENANCE	6-3.	Responsibility	Requires surface and groundwater agreement Establishes enforcement procedure
		6-4.	Prohibitions	Establishes penalties
		6-6.	Design for Maintenance	Establishes procedures for sizing, design, and maintenance of easements
IV.	DEVELOPMENTS-WATERCOURSES	6-10.	Definition	Defines bridge and culvert
		6-11.	Sizing	Established method to determine peak rate of runoff
		6-14.	Delayed Run-Off	Requires private construction of detention basins with public technical assistance
VI.	GROUNDWATER	6-17.	Wet Areas	Defines wet areas Requires methods to drain
VII.	GRADING FOR DRAINAGE	6-18.	Yards and Other Surfaces	Requires lines and grades approval and provides specific requirements

Table 6

CHANGES IN DRAINAGE CODE EFFECTED BY VARIOUS ORDINANCES
(Post Phase II Changes)

Article	Section	Type of Change	Effective Ordinance
I. IN GENERAL	6-1. Objective of Chapter	Adds objectives	74-71
	6-2. Liability of County	Adds statement and sets standards for compliance	69-17 77-116
III. FLOODPLAINS	6-7. Definitions	Defines "development" and "substantial improvement"	77-91
	6-9. Restrictions	Establishes construction requirements for exceptions, criteria for variance to above requirements; and provides additional criteria for floodplain delineation	74-206 77-91
IV. DEVELOPMENTS-WATERCOURSES	6-13. Stabilization	Adds preferred alternatives	74-71
	6-15. Watercourse Improvements by New Castle County	Establishes qualification criteria, approval procedure, and design considerations	74-71
VII. GRADING FOR DRAINAGE	6-18. Yards and Other Surfaces	Requires sediment and erosion control plan, applies lines and grades requirement to building permits issued before 1969 and establishes penalties for violation	74-71
	6-20. Floor Elevations	Revises flood elevation criteria	74-206

Dissatisfaction with the Code remained, however. The objectives addressing water quality preservation and the promotion of groundwater recharge were not fully implemented. In addition, members of the original Committee realized that although the Code managed runoff very well, it did not allow the County to control its quality or put it to other uses. Furthermore, the Code specified that the cost of off-site facilities would be divided among upstream users, yet there were no basin plans to indicate off-site needs and no cost-sharing formulas to guide the process. Most of the cost was thus borne by the general public.

3. NEED FOR CONJUNCTIVE PLANNING

Drainage cannot be viewed as a single program, nor can agencies involved with drainage see each respective geographical segment of a drainage system as their only responsibility. Because upstream and downstream flooding are related, a regional view of the problem is essential. Management agencies must coordinate objectives and technical methods if solutions are to last. In the same way, the broader impacts of a drainage program upon water quality and supply must be viewed in the same comprehensive context. New Castle County realized these needs and initiated steps to meet them.

3.1 WATER QUALITY

New Castle County was one of the first recipients of an area-wide water quality planning grant under Section 208 of P.L. 92-500. Work under this grant was conducted by the Office of Water and Sewer Management (an office of New Castle County's Department of Public Works) which held responsibilities for both water supply and water quality planning. A major study was conducted that showed stormwater runoff to be a principal non-point source of water pollution. The data, principally of sediment losses, indicated that agriculture, construction activities, and urban runoff, in that order, were the major sources.

Because sediment was a pollutant whose origin was easy to document, control was relatively easy to justify. Construction sources were addressed by the Sediment and Erosion Control Sub-Committee of the Drainage Committee which produced the Guidelines. Agricultural sources were addressed by the New Castle Conservation District and the 208 Program with funding from the Environmental Protection Agency and the Department of Agriculture. A program to apply conservation planning to watersheds is presently in progress.

Urban runoff control, however, is less easy to justify because legalities and treatment methods have required precise measurement. The pollutants contained in urban runoff are extremely difficult to measure and combine with pollutants from different sources. Furthermore, none of the existing data collection efforts in the County had attempted to measure it or rank its severity against either agricultural or construction site runoff. As a consequence there was no program in place to implement objective four of the Code which addresses protecting water quality from runoff.

3.2 WATER SUPPLY

As the water quality work proceeded, the 208 Program also documented a shortfall between peak demand and safe yield for a number of water distribution systems in the County. In recommending solutions from among the alternatives, it found that the "soft technologies" which husband the resource (water conservation and groundwater recharge) were among the most cost-effective means to augment the County's water supplies.

Water supply was also a concern of the State because it had to allocate ground and surface withdrawals. Domestic and industrial needs, wildlife, recreation, aesthetics, and water quality competed keenly for the resources.

At the same time, the Department of Planning was attempting to develop a land use policy to protect major aquifers. Competing against permanent protection of these areas was the demand for development. Because of the size of the aquifers, land acquisition was out of the question, and consideration of prohibitions threatened to raise the "taking issue." It seemed to be in the best interests of the County to find a means to regulate development in these areas through a comprehensive water management policy. What that would be is still under discussion.

3.3 FISCAL MANAGEMENT

Both the County Council and Department of Public Works have grown concerned with the cost of drainage facilities and who should pay for them. A study conducted at the University of Delaware in 1974 argued that drainage facility costs to the County would rise as an area reached full development and that certain costs such as operation and maintenance would continue indefinitely even after the basin was fully "improved" (Minnehan, 1974).

According to the study, drainage needs are created by developers in upstream areas who change the basic land use and install on-site drainage facilities to rid the site of surplus water. After some time passes and more development occurs, the County might need to construct new drainage works to correct or remedy a drainage problem in the same local area, upstream. Subsequently, the County acquires a responsibility for repairs and/or improvements to this structure as well as maintenance costs. Projects, repairs and improvements, and maintenance are three main cost areas in the County budget. Downstream, the same set of maintenance costs can also accrue.*

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*The effect of the present Code has been to reduce cost increases largely through imposing higher and more consistent standards on developers, such as detention facilities. Still, the question of who should pay to maintain these facilities or to construct downstream facilities, repairs, or corrections has not been answered in a satisfactory manner.

The public also pays for other drainage costs. In addition to the County's share are projects, studies, and services incurred by the Soil Conservation Service, generally in upstream areas, and by the Corps of Engineers in downstream areas. Wilmington and Newark also incur costs, and the Department of Transportation's Division of Highways has a substantial drainage budget as well.

Conversely, the consequences of policies that encourage drainage are also subject to increasing costs. Long-range water supply plans indicate that with present supply and demand patterns, New Castle County cannot expect to meet its needs without major storage facilities. A more efficient use of existing supplies could forestall these needs for the indefinite future. Better stormwater management could well be one those efficient uses.

It has increasingly been shown that policies which expedite runoff from the land are not in the best interests of sound fiscal or water management. Such policies have been based on the premise that water is a common enemy. To view water differently, that is, as an asset, means different technical guidelines must be developed and the legal bases for runoff disposal must be examined to see if new legislation is needed. The conflict arises in the use of streams for transporting water and wastes. Downstream property owners seek to use the area along the stream for residential and commercial purposes while upstream groups seek to use it as a drainage system to carry off storm runoff. Point and non-point sources dischargers compete for the limited assimilative capacity that is available, and water consumers want undiminished quantities of the highest quality.

Meeting the various demands for using drainage systems and the waters they carry does not lend itself to a neat benefit-based allocation. A common-sense approach has now been outlined in local work programs that maximizes the volume of water to serve these purposes by minimizing wasted water due to high volumes of runoff. Storage in soil and aquifers of all types will be investigated in a systems approach that uses the hydrologic cycle as the model to manage the runoff-recharge response of the County's watersheds. Administration of a drainage code according to the premises of this model would keep rainfall close to where it falls. Such an approach requires a major reevaluation of the objectives of the Drainage Code, its technical criteria, standards, and procedures. Some of the preliminary ideas of that reevaluation are discussed in the following section.

4. NEW DIRECTIONS

If the objectives of water quality protection and encouragement of recharge are met, greater attention must be given to the volume of runoff from developed areas and how it is managed. Design criteria set for volume can (1) discourage practices that expedite flow to the nearest stream and (2) encourage land treatment methods to retain and filter urban runoff for groundwater recharge.

4.1 PREDEVELOPMENT BASELINE

Traditionally, the concern in sizing drainage facilities has been to control surplus runoff originating from impervious surfaces. This problem has generally been solved by reducing the runoff peak to the rate expected from the land in its predeveloped state under design storm conditions. Existing land use is generally considered to be the predevelopment baseline, and agriculture, particularly row crops, is the existing land use in a majority of cases.* Agriculture has already increased runoff and decreased recharge over natural, e.g. forested, conditions (Dils, 1953). Using agriculture as the baseline instead of forest reduces drainage requirements to an accounting of the change in characteristics produced by impervious surfaces and a managing of the peak created by that change. Recharge on the site's pervious surfaces may increase as lawns with good infiltration replace crops. For densities up to 4 or more dwelling units per acre, total recharge in urbanized areas may in some cases be slightly greater than in agricultural areas.

4.1.1 PROCEDURES. To show the enormous effect of using an agricultural baseline for design purposes, runoff and recharge were compared for several land uses using a procedure outlined by the U.S. Soil Conservation Service (SCS) (Mockus, 1964). In it, direct runoff can be determined from accumulated rainfall if the soil characteristics and cover complex are known. This approach was used on an hourly basis for the rainfall from a 10-year, 24-hour storm (5.2 inches of precipitation) whose temporal distribution (hyetograph) was determined from the Corps of Engineers design distribution pattern (Turner, Collie and Braden, 1976).

A computer model was developed which would employ the SCS procedure using soil and land use data from the New Castle County Automated Environmental Resource Information system (AERI), a geobased system of 500 foot (5.7 acre) grid cells. The model considered only the predominant land use of each cell to determine accumulated point runoff and infiltration on an hourly basis.

4.1.2 TEST SITE. Belltown Run Basin, located in south central New Castle County, Delaware, was the focus of this pilot study

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*Cash grain farming with little management, corn and soybeans predominating, is the most extensive agricultural activity in New Castle County.

(Figure 1). This basin is virtually undeveloped, and of its 4,800 acres, agriculture is the dominant land use.

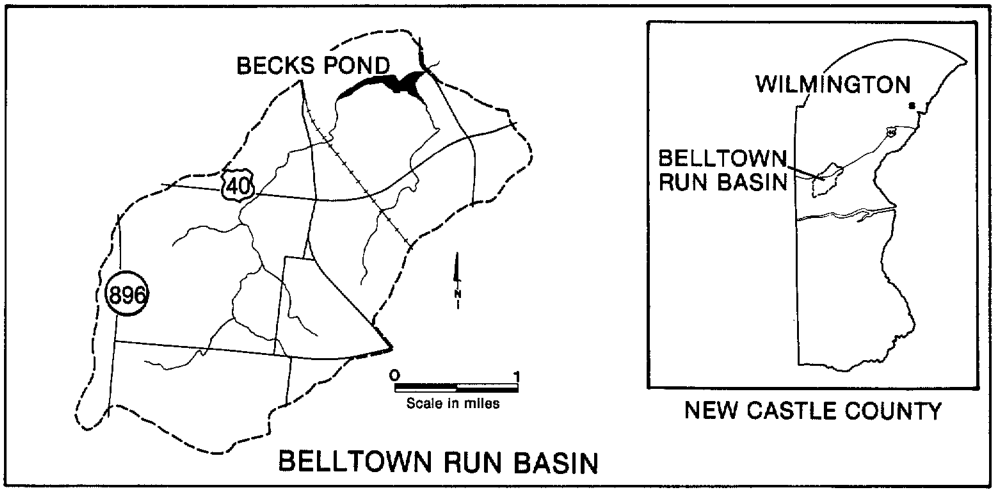

Figure 1

Infiltration comparisons were made between three hypothetical land uses in this basin: (1) total forest, (2) composite forests and agriculture, and (3) total agriculture. These data indicate that, as expected, when landscape changes from forest to agriculture, runoff increases (Figure 2).

CUMULATIVE PRECIPITATION AND INFILTRATION:
Belltown Run Basin (SCS Procedure)
Based on 10-year frequency, 24-hour storm with 5.2" of precipitation.

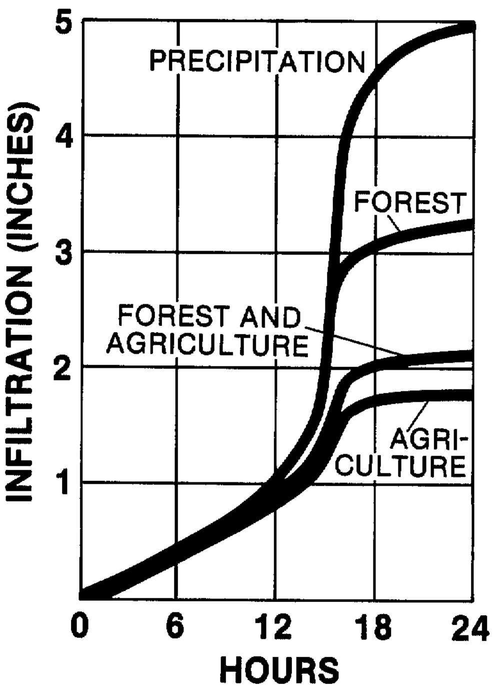

Figure 2

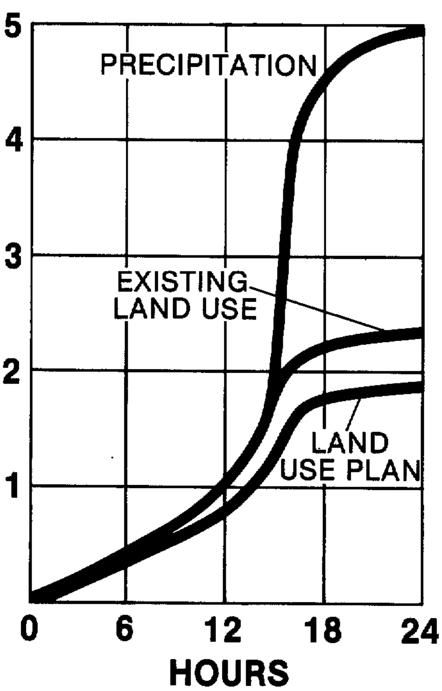

Figure 3

Comparing the data and the infiltration curves of Figure 2 with the same information for existing land use and the fully developed land use plan (Figure 3) shows that urban runoff and recharge relationships in Belltown Run are more closely akin to the agricultural rather than the forested relationships. Existing land use produces less runoff than the full agricultural basin because a substantial amount of the basin is still forested. A fully developed land use plan, however, reduces forest and eliminates all agricultural lands. Runoff and infiltration from this land use pattern is approximately equal to the totally agricultural land use pattern (Table 7).

Table 7
RUNOFF AND INFILTRATION RATES FOR VARYING LAND USES, SCS METHODOLOGY

Land Use	Runoff In %	Infiltration In %
Forest	36.1	63.9
Part forest, agriculture	57.9	42.1
Agriculture	64.3	35.7
Existing	54.6	45.4
Plan	63.7	36.3

The results suggest that the use of forest as a baseline to regulate the volume of runoff would reduce direct runoff from a fully developed basin by one-third and would thereby store substantial amounts of water in the soil. Additionally, the use of such a baseline would add substantial costs to the traditional approach of controlling peak flow and providing storage.

It is recognized that use of a forest baseline would raise the costs of drainage and stormwater management to the developer which, in turn, would be passed on to the consumer in the form of increased housing costs. Concern for the homeowner is legitimate, but it need not preempt the adoption of environmentally desirable regulations. The issue is the location of the responsibility for restoration of infiltration rates to their former levels and how to place this responsibility.

New drainage baselines have the effect of creating new markets for farmland that has been well-managed because of savings in drainage costs. And, vice versa, declining markets may result for land that has been poorly managed. This problem should be addressed wherever farm management planning is practiced* since runoff must be retained in order to reduce soil and agricultural chemical losses. Farm management planning is an important adjunct to any contemporary drainage program. What means exist to provide the necessary storage for water that must be retained?

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*Farmers in two basins in New Castle County now participate on a voluntary basis in a conservation program jointly conducted by the New Castle Conservation District and the Water Resources Agency.

4.2 STORAGE CAPACITY

The SCS procedure presupposes a specific amount of storage capacity in soil not covered by impervious surfaces and varies this for each of three antecedent moisture conditions. It does not take into account the total storage capacity remaining in the soil covered by impervious surfaces and in the geologic materials that lie beneath the soil layer. To analyze the effect of additional storage on runoff and infiltration, the SCS procedure was expanded to account for the soil moisture storage capacity of the unsaturated water table aquifer without constraints on soil infiltration rates (i.e. if groundwater recharge were practiced to its fullest capacity). For the Belltown Run example, the unsaturated aquifer thickness was developed with the assumption that the soil-aquifer interface occurs at a uniform depth of 48 inches. This thickness was then related to a specific yield based on the particle size of the material (Johnson, 1967). Determined runoff relationships are again graphically summarized (Figures 4 and 5).

CUMULATIVE PRECIPITATION AND INFILTRATION:
Belltown Run Basin (SCS Procedure with Water Table Aquifer Storage)
Based on 10-year frequency, 24-hour storm with 5.2" of precipitation.

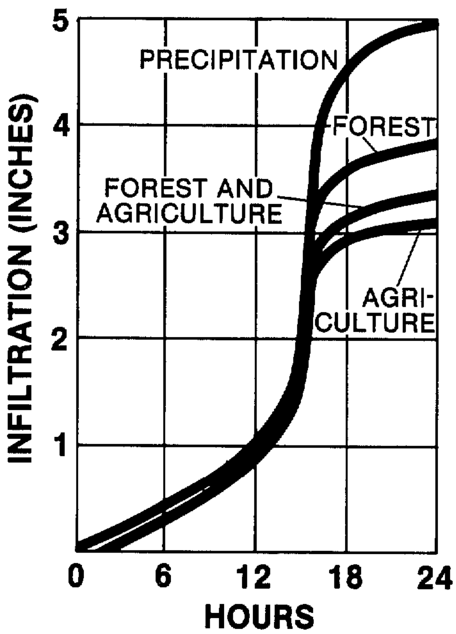

Figure 4

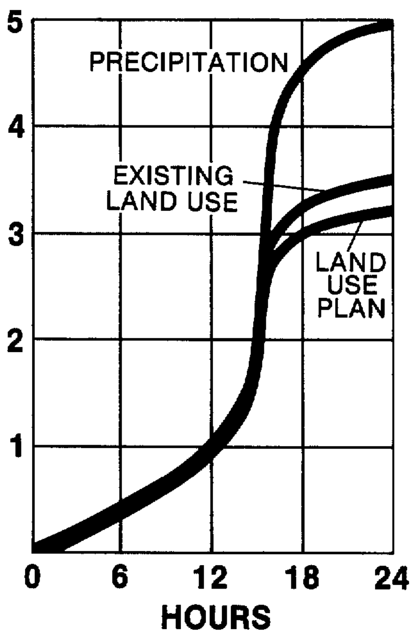

Figure 5

Comparison were again made among the three hypothetical land uses and between existing land uses and the developed land use plan. These data indicate that runoff from the basin would decrease for all land uses if a means existed to recharge the water table through inhibiting soil layers (Table 8), and infiltration would be substantially higher.

Table 8
RUNOFF AND INFILTRATION RATES FOR VARYING LAND USES ASSUMING EXPANDED MOISTURE STORAGE CAPACITY

Land Use	Runoff In %	Infiltration In %
Forest	23.8	76.2
Part forest, agriculture	34.3	65.7
Agriculture	38.1	61.9
Existing	32.8	67.2
Plan	37.4	62.6

The results also suggest that the amount of storage in the geologic materials may be sufficient to attenuate the rate of runoff of a fully developed land use plan to the level of a forested basin under natural conditions (62.6 vs. 63.9 percent of precipitation). Reductions in drainage costs might be achievable as well (Lindley, 1974). Other benefits lie in augmenting groundwater supplies, baseflows, and assimilative capacities and in providing opportunities for treatment of urban runoff. Infiltration systems have, for example, been found particularly effective in reducing BOD, suspended solids, total coliform, and nutrients as compared to a variety of source controls, collection systems, and storage and treatment (Turner, Collie and Braden, 1976).

There are problems associated with not managing the volume of runoff as well as with managing it. Unless runoff volumes are to be maintained at predevelopment levels, problems will still occur in the stream. The problem that occurs is one of high flows and erosive velocities due to overlapping flood peaks from tributaries. On-site detention can keep the flood crests in the smallest tributaries at predevelopment levels but, because of added volume, the flood crests are maintained for a much longer duration. The longer tributary flood crests begin to overlap in the main channel and create higher and longer flood flows than in the undeveloped or only partially regulated basin.

Recharge practiced on a more widespread basis undoubtedly will raise the water table and could affect basements, septic system drainfields, the location of the frost zones and the construction of buildings and roads if practiced indiscriminantly. Similarly, surface storage has an undesirable effect. The value given to these costs and inconveniences must be weighed against the value of water management benefits. There is no substitute for reasonable application of infiltration techniques and supplemental offsite facilities.

In the New Castle County Drainage Code, recharge is considered a viable option for managing surplus water, and technical exhibits to demonstrate feasibility are specified. Recharge, however, is not widely practiced. There is no requirement for recharge even in major recharge areas. No guidelines have been prepared, and there is no incentive, economic or otherwise, to use such techniques. Correcting these situations will depend upon more widespread interest in the water supply and quality benefits that may be achieved. What means exist to encourage use of this storage capacity?

4.3 CHANGE IN IMPERVIOUSNESS

A local government's drainage code has to be flexible enough to be administered through piece-meal decisions without losing sight of its objectives. Recharge concepts are not new. A number of model projects have illustrated entire systems of techniques. What would be significant, however, is a drainage code which recognizes that the purpose of drainage facilities is to manage the byproduct of changes in the impervious character of the land. Whether by direct regulation or creation of a public utility, the cost of drainage should fall most upon the individual or activity that increases drainage responsibilities most.

Stormwater financing raises many questions. How are the administrative and construction costs of a stormwater management program to be funded? What costs are to be included or excluded? How will the costs of specific improvements be allocated between developer, principal beneficiaries, and the general public?

The key issue is the last. Use of property taxes, general obligation bonds, special assessments, or federal funding presumes a definition of equity and efficiency that may not match with the objectives of stormwater management as illustrated here. What costs are or are not included is merely an accounting procedure with its own rationales. If the objective of stormwater management is to restore the hydrologic response of a watershed to its natural condition, the financing issue revolves around the use of fiscal means, specifically cost allocation, to accomplish that objective.

Restoring the hydrologic response typical of a natural landscape requires a drainage code that regulates recharge and a financing procedure that encourages recharge. The approach must assess each individual according to the "benefits" received. Some guiding principles are (King County, 1977):

(1) Any user charge system should be tied to use of the system.
(2) All users should pay.
(3) All charges should be for current use.
(4) Land in its natural state should not be charged.
(5) The system of charges should provide incentives for sound development which does not aggravate surface water problems.
(6) The system of charges should be relatively inexpensive to implement.

What we suggest in this paper is that equity and efficiency work together, provided that we re-define "benefit." Benefit means to change the imperviousness of the watershed by a choice of land use which places a demand on the stream to carry away storm runoff and pollutants. Some jurisdictions finance on the basis of amount of impervious surface, but this would seem equitable only in areas where the natural perviousness of the watershed was relatively uniform. For a watershed that is not, this method could result in some inequities. Figure 6 shows how change in runoff volume is a function of the hydrologic characteristics of a soil as well as the percent of imperviousness of a given land use.

EFFECTS OF IMPERVIOUS SURFACE ON TOTAL RUNOFF FOR SCS HYDROLOGIC SOIL GROUPS
Based on 10-year frequency, 24-hour storm with 5.2" of precipitation.

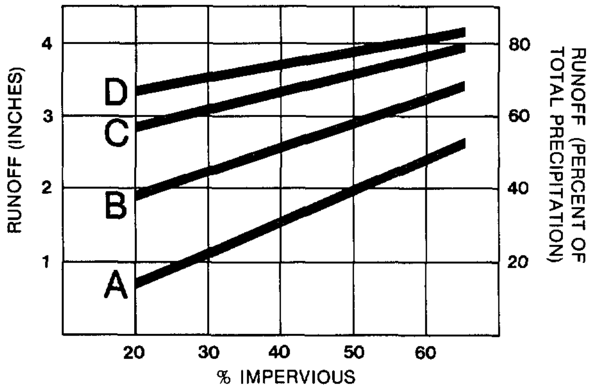

Figure 6

A financing method based on both impervious surface and hydrologic soil characteristics could meet the test of equity, since the problem of non-uniform soils is taken into account. This method is economically efficient in that it promotes the utilization of groundwater recharge techniques by making it economically advantageous to avoid drastic changes in the hydrologic cycle. It thereby protects primary aquifer recharge areas and assures greater quantities of recharge/infiltration for base flow and assimilative capacity augmentation. The essential element of this fiscal policy is a belief that the Lord did not create all lands equally and that it is in the interests of good fiscal and environmental management to treat changes in the hydrologic cycle accordingly.

The administration of this practice is shown in Figures 7, 8, and 9. Figure 7 shows the SCS procedure applied to calculating infiltration under a forest cover. The map indicates the quantitative distribution of potential infiltration and thereby indicates where the change in imperviousness would have the greatest effect on runoff. This Figure could be a guide to determining drainage and recharge requirements.

EFFECT OF LAND COVER AND SOILS ON INFILTRATION:

Belltown Run Basin (SCS Procedure)
Based on 10-year frequency, 24-hour storm with 5.2" of precipitation

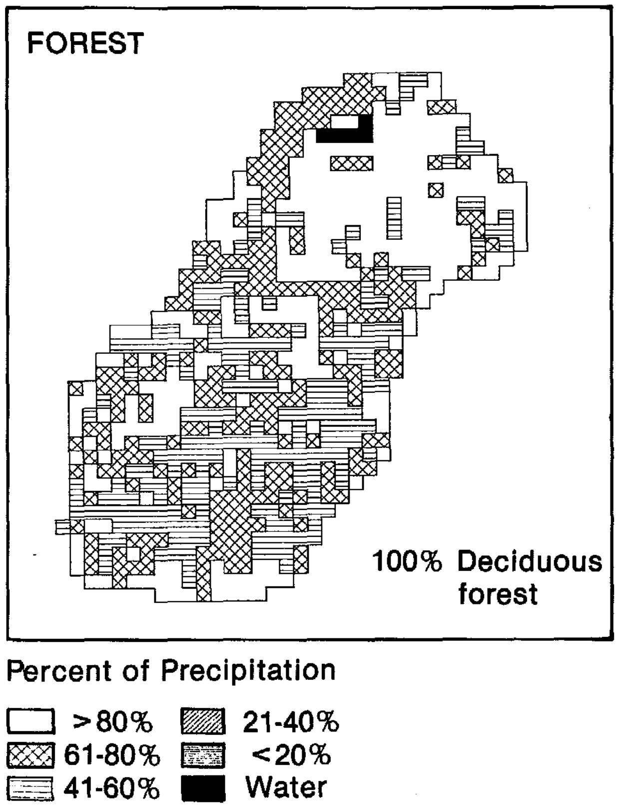

Figure 7

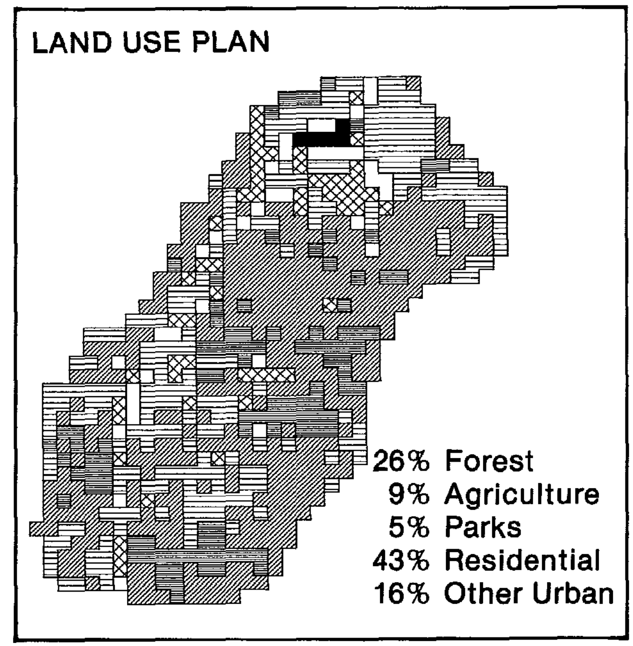

Figure 8

EFFECT OF LAND COVER AND SOILS ON INFILTRATION:
Belltown Run Basin (SCS Procedure with water table aquifer storage)
Based on 10-year frequency, 24-hour storm of 5.2" pf of precipitation

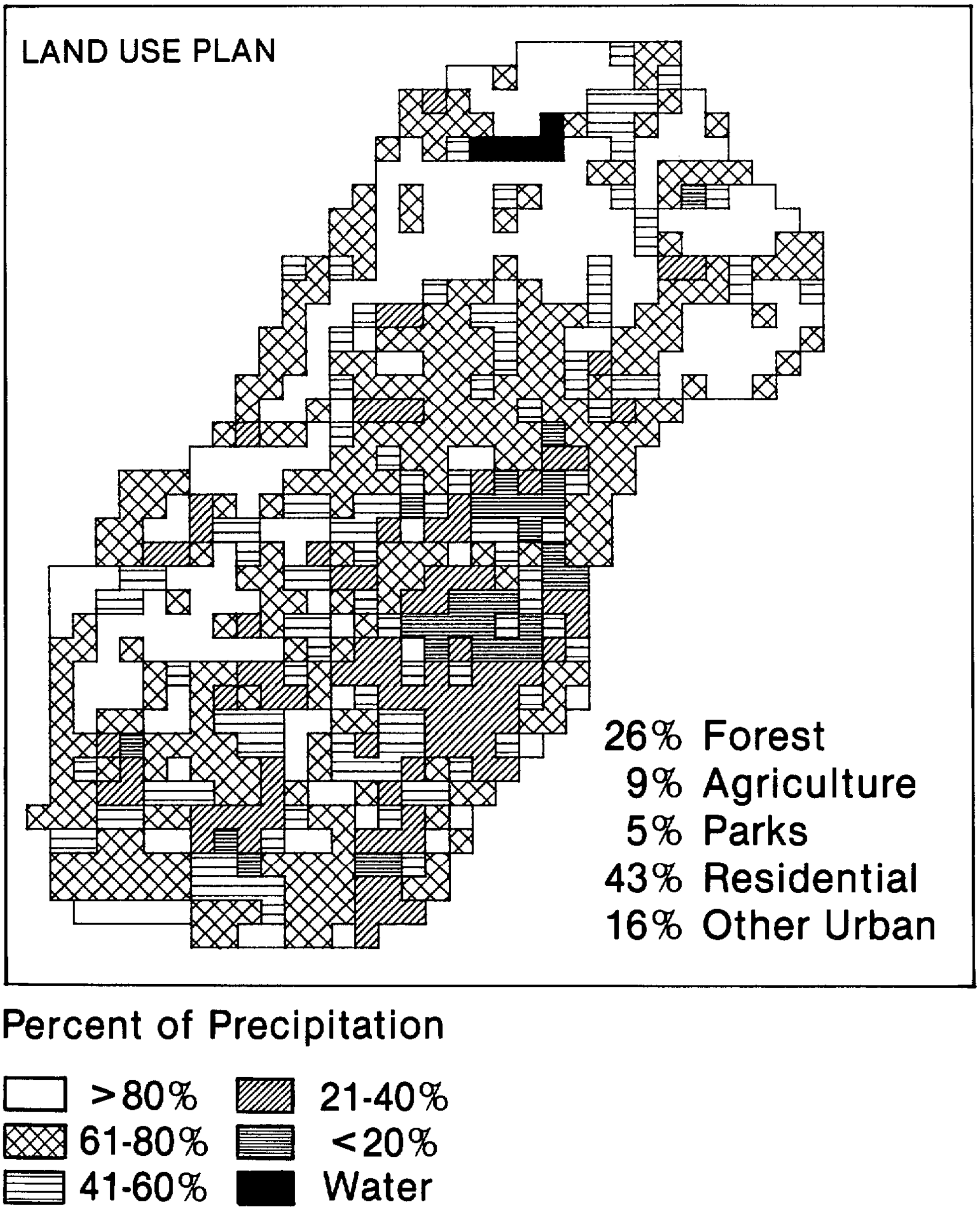

Figure 9

Figure 8 shows the SCS procedure applied to the developed land use plan. Overall, runoff is much higher and is approximately equivalent to the runoff of a totally agricultural basin. This map reflects the distribution of infiltration as a result of a change in land use and traditional drainage practices. Depending on the land use, a given soil may yield different volumes of runoff, and vice versa.

Under the assumption that the hydrologic impact of a change in imperviousness must be controlled to the forest level, methods to utilize the storage capacity in the Pleistocene sediments might be investigated. Figure 9 illustrates the effect that storage capacity has on infiltration, assuming techniques were utilized to access this capacity. Infiltration in the sediments is sufficient to restore total basin infiltration to the forested level. The pattern of infiltration differs because it is the sum of the effects of land use, soil, and storage capacity.

Land use choices obviously limit the opportunities for recharge. However, the requirement for volume control should remain the same for all lands, that is, to maintain volume and peak runoff at the forested level. In administering the requirement, it should be expected that conventional drainage techniques must supplement recharge techniques where opportunities are limited. All on-site facilities would be the responsibility of the individual changing the hydrologic character of the land. Off-site facilities, where needed, would be financed in proportion to their use by individuals who need supplemental drainage. In this way, the cost of off-site drainage facilities is greatest on lands with good recharge properties. Change in impervious surface can be determined at the project evaluation stage, whereupon a fee could be assigned based upon drainage plans for the watershed (according to common practice).

5. SUMMARY

A chronology of events was outlined earlier which showed New Castle County's comprehensiveness in dealing with drainage problems. The first attempts at a drainage program focussed on expediting flow from a watershed. An attempt is now underway to reverse some of that earlier thinking. Water supply and quality considerations have gained in priority as part of the contemporary drainage program.

Ideas were also outlined for addressing the water supply and quality concerns, and a fiscal policy was discussed as an important adjunct to a regulatory process built around new technical baselines, procedures, and criteria. An optimal situation was presented to convey the ideas if not their technical details.

Most importantly, a strong case was made for setting environmental criteria (forest runoff and infiltration relationships) as the baselines for managing the hydrologic response of a watershed. Volume control is the primary consideration. Use of other baselines, such as cropland, sets too low of a standard for volume control. SCS procedures are discussed they relate to initial assumptions in drainage facility design. Lacking data for recharge potential, such procedures can underestimate the volume of runoff that can be managed. Such underestimation biases drainage controls in favor of structural rather than non-structural controls simply due to the volume of water that must be managed offsite. Finally, the argument has been made that the change in runoff by impervious surface construction should be the basis of the regulatory and fiscal, elements of a drainage code.

Each community must determine what goals and objectives it seeks for drainage management, that is, whether multiple water use shall be part of the implmentation procedure. In recognition of pollution and sedimentation from farmland, several states have passed or are considering legislation to set mandatory controls on soil erosion which specify performance and other details. The idea of setting mandatory limits for soil or runoff from the land is not new. All that is new is the use of environmental baselines for standards.

As a minimum, each community must look at opportunities in future land development for rectifying past inattention to water supply and quality considerations. The entire issue of control of urban runoff quality is much larger, involving established neighborhoods, combined sewers, and other complexities too involved to deal with here. A contemporary drainage code, however, would use the hydrologic regime as the key to the management system and as an orgainzing concept for development of drainage basins. We can do more to prevent repetition of past mistakes by such procedures, and thereby attain the most cost-effective program overall.

Legalities may be the most significant institutional barrier to overcome (Poertner, 1975). Each of the three drainage laws in the U.S. permits a landowner to enhance the drainage of his property so long as he does not act unreasonably or negligently. The preponderence of modern legal cases treat surface water interference on the theory of private nuisance which causes injury to a person in the enjoyment of his estate. The degree to which an individual can drain his property is limited by a balancing of relative benefit and harm (i.e. reasonable use is permitted). Following this line of reasoning, it is often suggested, somewhat perversely, that downstream property owners reimburse upstream owners for detention facilities. This is based on the premise that any reduction in runoff required of the upper owner confers a benefit (reduced flooding) on the downstream owner which he or she should pay for. The "reasonable use" rule is the reason the water law property concept is robbed of much of its effectiveness as a tool for pollution control, flood control, and recharge. An ordinance authorizing storm sewers, for example, endorses this rule and could arguably be construed as taking the disposal of surplus water and pollution of streams by stormwater discharges out of the nuisance category.

Recharge has been recognized by engineers primarily as a technique to control runoff to the level of "reasonable use." To achieve a higher standard of volume control would not be necessary under existing drainage laws. In arid climates the possibility of of altering what might be perceived as the "natural" runoff raises one kind of question about the rights which pertain to runoff water. And to design and construct for recharge raises still other questions about liabilities. In view of these questions and present drainage law, it is not surprising that most individuals view drainage rather than recharge or restoration as the basic problem in land development.

6. ACKNOWLEDGMENT

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AREAWIDE AND LOCAL FRAMEWORKS FOR URBAN NONPOINT POLLUTION MANAGEMENT IN NORTHERN VIRGINIA

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Introduction

Background

The 580 sq mi Occoquan River Basin is a major tributary of the Potomac Estuary located on the southern periphery of the Washington, D.C. metropolitan area. Figure 1 shows a generalized map of the urbanizing basin, which traverses four counties and two cities and is situated astride the Piedmont Upland and Piedmont Lowland geologic provinces. Mean annual rainfall in the basin totals approximately 40 inches.

Table 1 compares the existing land use pattern in the basin with Year 2005 projections. As may be seen, local land use projections indicate that urban development will increase from 10% to 24% of the basin's total land area by the Year 2005.

The 9.8 billion gallon Occoquan Reservoir, which is located at the mouth of the basin, is one of the few major water supply impoundments in the Eastern United States that is located downstream from an urbanizing region. It was constructed in 1957 to meet the growing water supply needs of the Virginia suburbs of the nation's capital. The Reservoir presently serves more than 640,000 customers in two counties and two cities in the Northern Virginia region.

In the late 1960's, classical symptoms of "cultural

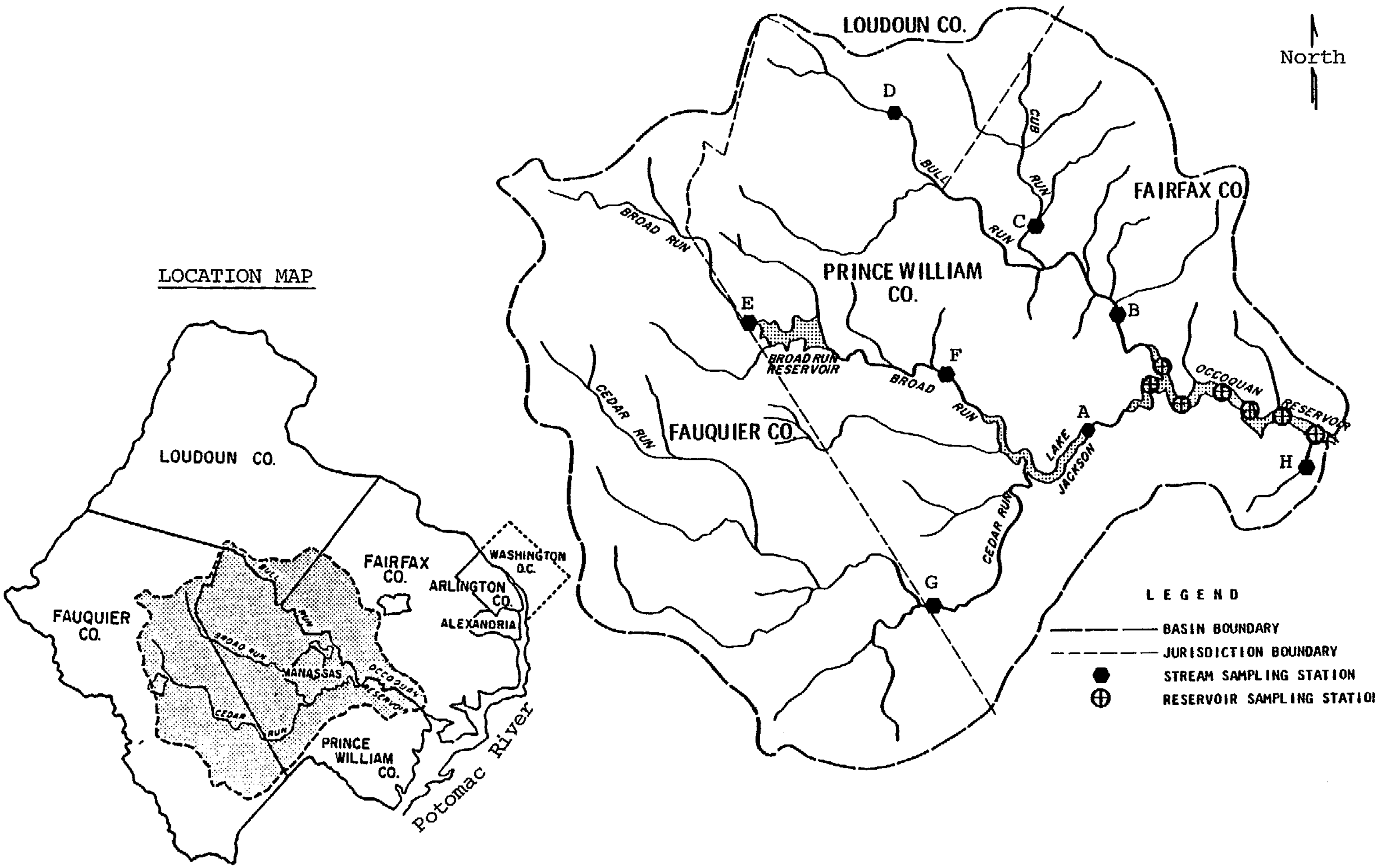


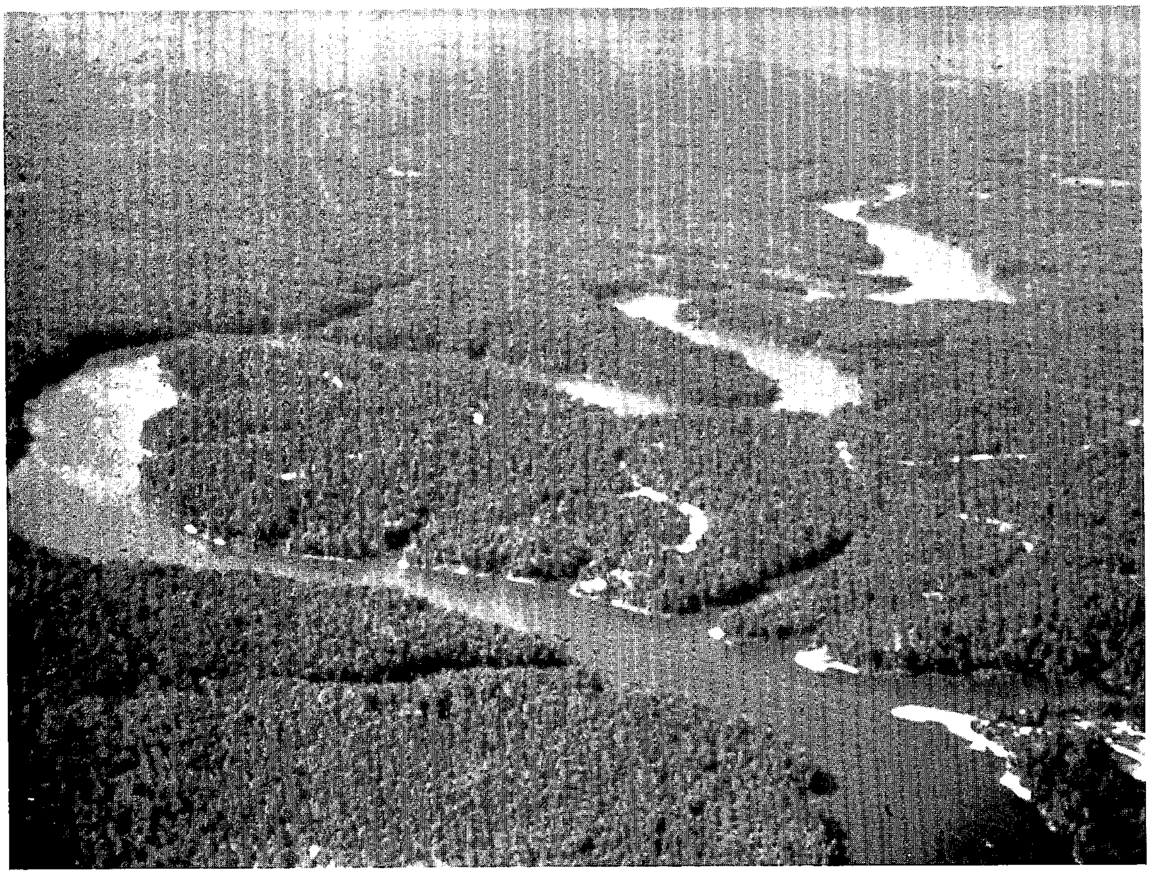
FIGURE 1. GENERALIZED MAP OF OCCOQUAN RIVER BASIN

TABLE 1
OCCOQUAN BASIN LAND USE PATTERNS

LAND USE	EXISTING (% of Total)	YEAR 2005 (% of Total)
Single Family Residential	7%	16%
Multifamily Residential	1%	2%
Industrial	1%	2%
Commercial	1%	2%
Institutional	1%	2%
Forest	48%	41%
Idle Land	7%	6%
Pasture	24%	20%
Cropland	10%	9%
TOTAL:	100%	100%

eutrophication" were observed in the water supply impoundment, characterized by periodic blooms of nuisance algae, oxygenless conditions in the lower layer of the reservoir, fish kills, and filter clogging at the Fairfax County Water Authority's water treatment plant. Following a one-year study (1) of water quality problems in the watershed, the Virginia State Water Control Board (SWCB) in 1971 promulgated a policy (2) for regional wastewater management which has proven to be one of the nation's most ambitious, far-reaching water quality management programs. The SWCB's "Occoquan Policy" required that the jurisdictions in the basin replace eleven secondary sewage treatment plants with a regional advanced wastewater treatment (AWT) plant which would provide 97% removal of nitrogen, 99.5% removal of phosphorus, and 99.5% removal of biochemical oxygen demand (BOD) and would be situated immediately upstream from the Occoquan Reservoir. The $82 million Occoquan AWT plant began treatment operations in July, 1978 at an initial capacity of 8 MGD. The 1971 Occoquan Policy included provisions for eventually expanding the plant to 39 MGD after it has been demonstrated that the AWT is consistently achieving sufficient point source control.

The Occoquan Policy was founded on the assumption (1) that secondary wastewater treatment plants and agricultural runoff represented the major sources of pollutants that were degrading the quality of Occoquan Reservoir waters. Consequently, at the time of policy promulgation, it was assumed that construction of the regional AWT plant would not only eliminate wastewater sources of the contaminants but that it would also reduce nonpoint pollution loadings by accelerating the conversion of agricultural lands to suburban development (1). However, subsequent studies by the Occoquan Watershed Monitoring Laboratory (OWML) and the Northern



Major objective of NVPDC's Occoquan River Basin Nonpoint Pollution Management Program is to minimize the impacts of impending urbanization on the long and winding Occoquan Reservoir, the principal water supply for the Virginia suburbs of Washington, D.C.

Virginia Planning District Commission (NVPDC) have indicated that while higher levels of wastewater treatment represent an essential ingredient of a basinwide water quality management program, the regional AWT plant should not be regarded as a panacea. These studies have shown that nonpoint pollution loadings of critical pollutants such as plant nutrients, organic materials, and heavy metals, are much higher than originally assumed and therefore, that nonpoint sources presently represent a significant contributor of pollutant loadings to the basin's receiving waters. In fact, these studies have shown that future urban development which is supported by the basin's AWT plant can be expected to increase, rather than decrease, nonpoint pollution loadings. In other words, it has become apparent that a basinwide nonpoint pollution management program is required to reinforce the benefits of the basin's wastewater management plan.

Scope of Paper

This paper describes areawide and local programs that have been established to manage nonpoint pollution in the Occoquan River Basin. The first section summarizes the 208 planning studies that laid the groundwork for nonpoint pollution management programs in the basin. The second section outlines the framework of the areawide management program which was established by the basin's local governments and water resources management agencies and is administered by Northern Virginia's regional planning agency. The third section presents a case study of a local management program developed by Fairfax County pursuant to the areawide management program and local water quality management objectives.

Areawide Planning Program for Occoquan River Basin

The 208 planning program for the metropolitan Washington region is coordinated by the Metropolitan Washington Council of Governments (COG). Since the Occoquan River Basin constitutes a multijurisdictional planning area with water quality problems which are quite different from those confronting other tributaries of the Potomac River and Estuary, COG authorized NVPDC, a submetropolitan planning agency, to coordinate the development of an areawide plan for the basin. The distribution of land area among the six jurisdictions located within the Occoquan Basin is as follows: Prince William County--40.1%; Fairfax County--17.8%; Fauquier County--35.5%; Loudoun County--4.9%; City of Manassas--1.4%; and City of Manassas Park--0.3%.

The NVPDC 208 planning program, which began in August 1976, was supervised by an advisory committee called the "Occoquan Study Group" composed of elected officials and senior staff representatives of the six jurisdictions located within the Occoquan Basin, a staff representative of the City of Alexandria which is one of the major users of the Occoquan Reservoir water supply, a representative of NVPDC, a representative of SWCB, representatives of the basin's local water and sewer authorities, and representatives of local and State agricultural and forestry management agencies. Since SWCB's 1971 Occoquan Policy had effectively eliminated point sources of pollution in the Occoquan Basin, NVPDC's 208 planning studies focused on the water quality problems which would not be addressed by the basin's regional AWT plant.

Characterization of Nonpoint Pollution Problems

NVPDC's 208 planning assessments of nonpoint pollution problems relied upon three related studies: an OWML monitoring study of nonpoint pollution loadings from 8 major sub-basins with mixed land use patterns; a follow-up field study of nonpoint pollution loadings from small watersheds with homogeneous land use patterns, which was conducted by NVPDC and Virginia Polytechnic Institute and State University (VPI&SU); and computer-based modeling studies of the Occoquan River Basin which relied upon nonpoint pollution loading data produced by the OWML and NVPDC/VPI&SU field studies.

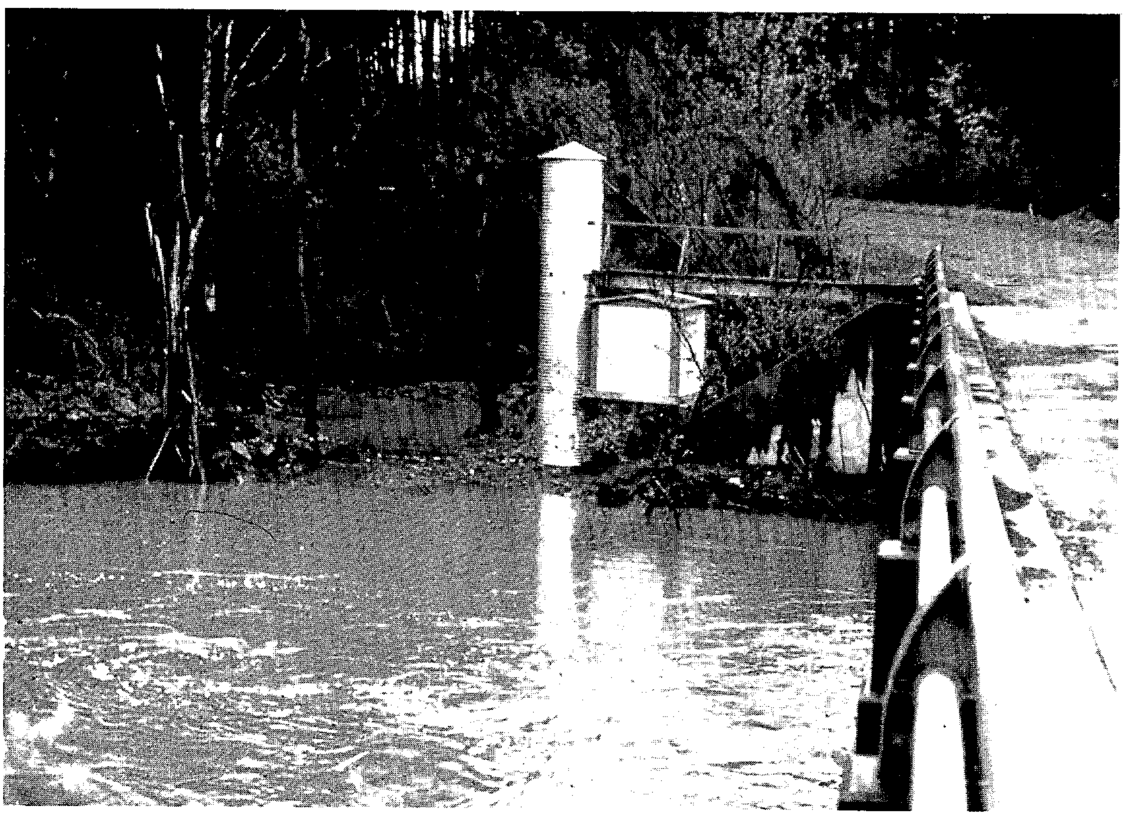
OWML was created by the SWCB in 1972 to establish surface water quality records that can be used to gauge the efficiency of the regional AWT plant. It has developed a continuous water quality record over a six-year period which adequately describes the trophic state of the Occoquan Reservoir and which has defined baseline water quality in the major tributaries. In addition, the use of automatic sampling equipment at the OWML stream monitoring stations shown in Figure 1 has permitted the development of an extended record of wet-weather loadings of plant nutrients and sediment produced in the basin. The monitoring stations are located on perennial streams draining sub-basins that range from 4 to 343 sq mi in size. Stations B, C, and H drain urbanized land areas, while station D drains an undeveloped section of the urbanizing Bull Run sub-basin. Stations A, E, F, and G drain rural-agricultural lands. Seasonal and annual loadings measured at Stations A and B from 1975 to 1977 permitted comparisons of point and nonpoint pollution inputs to the Occoquan Reservoir for pre-AWT plant conditions and of nonpoint pollution loadings from urbanizing (Station B) and rural-agricultural (Station A) study areas.

In June 1976, NVPDC and the Civil Engineering Department of VPI&SU initiated a more intensive field study of relationships between land use and nonpoint pollution (3). This study was a logical extension of the OWML monitoring effort which had documented the significance of nonpoint pollution loadings in the Occoquan Basin and had suggested certain cause-effect relationships that required further testing. The NVPDC-VPI&SU study was intended to identify the specific sources of the runoff pollution loads recorded at the OWML stations and to identify some of the physical characteristics that determine the response of each source to rainfall. The twelve-month field study was funded by the COG 208 planning program to develop nonpoint pollution loading data that could be applied throughout the Metropolitan Washington region. Runoff from 21 small watersheds (26-acre average) draining homogeneous land use patterns was monitored for the following nonpoint pollutants: plant nutrients, BOD, chemical oxygen demand (COD), heavy metals (e.g., lead, zinc), sediment, and fecal coliforms. The distribution of monitoring sites among urban and rural-agricultural land use classifications was as follows: 5 single family residential watersheds, 4 townhouse-garden apartment watersheds, 3 high-rise residential watersheds, 3 shopping center watersheds, 1 central business district watershed, 1 construction site, 3 agricultural watersheds, and 1 forested watershed. Thirteen of the watersheds were located in the Occoquan Basin at installations upstream from existing OWML monitoring stations. To project the impacts of dense urban development that is currently being proposed for the Occoquan Basin, eight additional watersheds were located in the more intensively developed Four Mile Run Watershed which is situated approximately 13 mi east of the Occoquan Basin.

NVPDC used the data produced by the OWML and NVPDC/VPI&SU field studies to formulate and calibrate the Occoquan Basin Computer Model (4,5,6), a sophisticated planning tool for isolating receiving water quality problems caused by nonpoint pollution loadings and for assessing the benefits of alternative management strategies. The Occoquan Basin Computer Model consists of a hydrologic/pollutant washoff submodel (7) and an instream process submodel (8). that utilizes the "land use-nonpoint pollution" relationships produced by the NVPDC/VPI&SU field study and vast amounts of data on the basin's soils characteristics, ground cover, drainageways, and hydrometeorologic conditions. The model consists of 15 sub-basins (39 sq mi average) that are linked by 12 idealized stream channels and 3 reservoirs. To assure that the model adequately describes the water resources processes in the Occoquan River Basin, certain model parameters were calibrated or "fine tuned" by comparing simulated and measured streamflow and water quality for selected periods. Comparisons of simulated and measured hydrologic data were based on a five-year calibration period (1971-1975) and a three-year verification period (1967-1970) at three streamgages in the basin, while water quality calibration was based on a three-year period of record (1974-1976) available at five stream monitoring stations and one Occoquan Reservoir station operated by OWML. The calibration and verification results were satisfactory, with discrepancies between simulated and measured values approximating the expected errors in the measurement of hydrometeorologic data and in laboratory analyses. Therefore, it was concluded that the calibrated model provides an adequate representation of hydrologic and water quality processes in the Occoquan Basin.

Summarized below are the nonpoint pollution problems in the Occoquan River Basin that have been identified by OWML monitoring studies, the NVPDC/VPI&SU field study, and applications of NVPDC's Occoquan Basin Computer Model.

<u>Plant Nutrients</u>. OWML's mass balance for seasonal and annual plant nutrient loads released into the headwaters of the Occoquan Reservoir during 1975-1977 highlighted the wide disparity between nonpoint pollution loadings and point source contributions (for pre-AWT wastewater flows and concentrations) with the former



Wet weather monitoring program operated by the Occoquan Watershed Monitoring Laboratory has helped quantify nonpoint pollution loads released into the Occoquan Reservoir by tributary streams.

contributing loadings that were often more than ten times greater than the latter (9,10,11). The disparity between nonpoint and point source contributions can be attributed, in large part, to the fact that urban point source discharges were relatively low (i.e., 5.1-6.7 MGD) during this period and were contributed by only 5%-10% of the basin land area while the nonpoint pollution loadings could potentially have been produced by the entire drainage area upstream from the Occoquan Reservoir. The mass balance also indicated that on a "per acre" basis, nonpoint pollution loadings from the urbanizing sub-basin (Station B) were as much as two times greater than the loadings from the rural-agricultural sub-basin (Station A). Results of the NVPDC/VPI&SU field study confirmed that annual unit area loadings from urban land use categories are considerably higher than loadings from forestland, pastureland, and cropland relying upon minimum tillage practices. Cropland relying upon conventional tillage practices produced the highest unit area loads of all land use categories. The NVPDC/VPI&SU field study also indicated that urban land uses with the highest levels of impervious ground cover exhibited the highest annual unit area loading rates, and that a significant percentage of plant nutrient loadings from all urban land uses was consistently in a dissolved form (i.e., unattached to sediment) with the mean dissolved loading in urban runoff ranging from 58% - 73% of the total load for nitrogen and from 31% - 55% of the total load for phosphorus.

A "half-empty bowl" effect within the Occoquan Reservoir during the spring, summer, and fall months, which can be attributed to drawdown of the water supply reservoir, allows nonpoint pollution loads produced by most rainstorms to be detained in the Reservoir following the storm event rather than released over Occoquan Dam. Receiving water studies with the Occoquan Basin Computer Model have indicated that in a year of average wetness, at least 50% - 60% of the plant nutrient loadings in runoff may be detained in the Reservoir long enough to have an adverse effect on water quality when quiescent conditions return. NVPDC's modeling studies of the nonpoint pollution impacts of existing and future (Year 2005) land use patterns have focused on loadings of phosphorus, which is considered to be the most critical plant nutrient in terms of Reservoir eutrophication. The modeling studies (12) have indicated that increasing urban development from 10% to approximately 24% of the total basin area, in the absence of any point source loadings or any nonpoint pollution controls, can be expected to: (a) increase annual phosphorus loadings from 86 tons/yr to 100 tons/yr for a year of average wetness; (b) increase mean chlorophyll *a* concentrations during warm weather months by 20% and maintain algal productivity at levels which are indicative of a eutrophic lake; (c) increase average annual accumulations of settled biomass (i.e., an indicator of lake eutrophication) by approximately 20%; and (d) cause oxygenless conditions in the lower layer of the Reservoir to persist for an additional seven days. In other words, future urban development in the absence of nonpoint pollution controls can be expected to increase, rather than decrease, the rate of Occoquan Reservoir eutrophication to levels which warrant concern, even after point source discharges of plant nutrients have been eliminated. In light of the impacts of Reservoir eutrophication on water treatment costs (e.g., taste and odor control, filter clogging), on the production of trihalomethanes during water treatment, on the sustenance and propagation of diverse aquatic life, and on water-based recreation opportunities, it was concluded that the management of plant nutrient loadings contributed by nonpoint sources promises significant benefits.

Oxygen-Demanding Materials. Field studies (3) of nonpoint pollution loadings in the Occoquan Basin have also demonstrated that stormwater runoff is capable of producing significant loadings of oxygen-demanding materials which can adversely affect aquatic life in the basin's streams and impoundments. Using the "land use-nonpoint pollution" relationships produced by the NVPDC/VPI&SU field study, NVPDC model projections of ultimate BOD and unoxidized nitrogen loadings delivered to the Occoquan Reservoir by nonpoint sources total approximately 3,744 tons/yr and 676 tons/yr, respectively, for existing land use patterns and a year of average wetness. By comparison, 1977 pre-AWT discharges from Bull Run's point sources (approx. 6.7 MGD) totalled approximately 96 tons/yr for BOD and 110 tons/yr for unoxidized nitrogen. Based on the NVPDC/VPI&SU field study, which indicates that on a "per acre" basis urban land use categories contribute higher BOD loadings than rural-agricultural land uses NVPDC modeling studies project that the Year 2005 development pattern in the Occoquan Basin will produce annual BOD loadings which are 15% greater than 1979 levels.

Heavy Metals. The NVPDC modeling study has also highlighted the impacts of heavy metals loadings produced by nonpoint pollution. Based on land use loading potentials defined during the NVPDC/VPI&SU field study (3), which demonstrated that nonpoint pollution loadings of heavy metals such as lead and zinc are positively related to the amount of pavement in an urban land use, the Occoquan Basin Computer Model was used to compare heavy metals impacts of existing (10% of basin in urban development) and future (24% of basin in urban development) land use patterns. Modeling studies of lead washoff and transport indicate that, in the absence of nonpoint pollution controls, average annual loadings on the basin's surface waters would increase from approximately 11 tons/yr to 27 tons/yr by the Year 2005. Since the NVPDC/VPI&SU field study demonstrated that 85% - 95% of the lead loadings in urban runoff is associated with sediment, it is anticipated that the majority of the increased lead loadings would accumulate in the bottom sediments of the basin's reservoirs and streams, where it could pose a considerable hazard to aquatic life in the basin's surface waters. Moreover, if lead loadings from urban development are not controlled, it is conceivable that nonpoint pollution loadings from the Year 2005 land use pattern could produce occasional violations of Virginia's raw water supply standard (0.05 mg/l) within the Occoquan Reservoir.

Fecal Coliforms. While the standard deviations associated with fecal coliform readings during the NVPDC/VPI&SU field study reflect the high variability in nonpoint pollution observations, the mean and maximum concentrations reported for urban land uses are high enough to suggest that runoff from future urban development patterns could produce fecal contamination levels which may restrict water-based recreation opportunities in the Occoquan Basin's receiving waters. Mean concentrations observed in runoff from urban land uses ranged from 12,000-16,000 MPN/100 ML for single family land uses to 137,000 MPN/100 ML for multifamily land uses, which exhibited a mean concentration that was slightly higher than the mean concentration of shopping center runoff (101,000 MPN/100 ML).

Sedimentation. The significance of sediment loadings delivered to the Occoquan Reservoir during wet-weather periods was documented during the OWML study (9,10). From July 1975 - June 1977, annual sediment loadings delivered to the headwaters of the Occoquan Reservoir (528 sq mi drainage area) averaged 75,500 tons/yr, despite the implementation of intensive erosion and sediment control practices at all construction sites and the fact that cropping practices occupy less than 10% of the total area within the Occoquan River Basin. In view of these significant loading rates, the potential reduction in Occoquan Reservoir storage capacity due to sedimentation provides further justification for nonpoint pollution management activities.

Trihalomethanes. OWML studies of the Occoquan Reservoir have produced data which suggests that the formation of trihalomethanes (THM's), a suspected carcinogen, during water treatment may be related to the level of reservoir eutrophication and the associated algal precursors which can be converted to THM's following chlorination (13). This relationship implies that a reduction in the rate of Occoquan Reservoir eutrophication through the implementation of nonpoint pollution management practices may produce reductions in THM concentrations in treated water.

More recently, a Fairfax County Water Authority (FCWA) report (14) on THM concentrations in treated water produced from the Occoquan Reservoir supply has highlighted the potential impacts of nonpoint pollution loadings. The FCWA report indicates that relatively minor treatment process modifications (e.g., changes in the point of chlorination) had succeeded in reducing THM concentrations measured during the winter and spring of 1979 to levels which met the drinking water standard (100 parts per billion) proposed by the U.S. Environmental Protection Agency (EPA). However THM concentrations measured in portions of the treated water distribution system during June and July 1979 were considerably higher than those observed during the months characterized by cooler temperatures and "substantially in excess of the proposed EPA standard." Since these THM levels have been noted during a period when point source inputs are extremely low due to AWT operations, it is conceivable that the relatively high levels of THM precursors which were apparently present in the Occoquan Reservoir during the 1979 algal growing season may be related to organic materials that are contributed by and/or produced from (i.e., due to algal productivity) nonpoint pollution loadings. In light of the high costs ($28 million capital cost and $650,000 - $800,000 annual O&M cost) that would be associated with the addition of granular activated carbon columns to FCWA's 65 MGD treatment plant in order to meet the proposed EPA standard, the implementation of nonpoint pollution management practices would appear to be an attractive option for THM management.

Comparisons of Point and Nonpoint Sources. It should be noted that any references to the impacts of point source pollution loadings during the pre-AWT period are intended primarily as a point of reference for gauging the significance of nonpoint pollution impacts rather than as evidence that one source of pollution is more significant than the other. While recent studies have shown that nonpoint pollution loadings, particularly those originating in urban areas, are much higher than originally anticipated, OWML has also shown that the basin's wastewater loadings can effect substantial water quality problems during extreme low flow periods (15). Studies of the Occoquan Reservoir during the drought of 1977, prior to the start-up of the regional AWT plant, showed that wastewater inflows from the basin's secondary treatment plants represented as much as 39% of the total monthly inflows to the Occoquan Reservoir during the latter stages of the drought and for several days in late September and early October represented as much as 90% of the daily inflows. As a result of the relatively high contributions of sewage treatment plant discharges, the Bull Run headwaters of the Occoquan Reservoir exhibited the most serious water quality degradation that had been observed since the start of the OWML monitoring program. Reservoir monitoring data collected by OWML since the AWT plant began operating in July 1978 indicates that the tertiary treatment facility will prevent the recurrence of water quality problems during subsequent low flow periods. Consequently, advanced levels of wastewater treatment represent a critical element in the Occoquan Basin water quality management program even if the seasonal and annual pollutant loadings from secondary treatment plants were relatively low in comparison with nonpoint pollution loadings.

Assessments of Urban Nonpoint Pollution Control Strategies

Characterization of Urban BMP's. Based on the characterizations presented above, the NVPDC 208 planning study concluded that uncontrolled nonpoint pollution loadings constitute a serious threat to the Occoquan Basin's surface waters and impoundments. The latter stages of the NVPDC study focused on assessing the cost-effectiveness of alternative nonpoint pollution management strategies. The NVPDC study relied upon the "worst case" assumption that nonpoint pollution controls would only be applied to urban development projected to occur between 1979 and 2005 for the following reasons: (a) it was felt that with the exception of street-sweeping programs in the basin's cities, retrofitting existing urban development with nonpoint pollution management facilities did not represent a very cost-effective management option; (b) comparisons of existing nonpoint pollution loadings and "controlled" loadings from future urban development were expected to be very helpful to those jurisdictions which were considering the use of land use controls to manage water quality in the Occoquan Basin; and (c) since rural-agricultural nonpoint pollution management programs will rely upon voluntary adoption of nonpoint pollution controls, it was felt that they could be ignored in the initial modeling studies to permit a detailed analysis of the benefits of urban controls.

Urban "best management practices" (BMP's) for controlling nonpoint pollution may be subdivided into four categories: (a) source controls: land use controls and maintenance programs (e.g., street sweeping) that minimize the accumulation and exposure of pollutants on the land surface and in the atmosphere during dry weather periods; (b) volume controls: BMP's that channel a specified volume of runoff and associated pollutant loadings into the soil profile where pollutant removal can occur through physical, chemical, and biological processes; (c) detention basin controls: BMP's that store stormwater and rely upon solids settling processes to remove sediment and sediment-related pollutant loadings; (d) stormwater treatment controls: BMP's that rely upon the addition of chemicals to stormwater storage basins to remove suspended and dissolved loadings which would not otherwise settle out in standard stormwater detention basins. The literature provides relatively little information on the efficiencies of BMP's and data that is available is not always transferable due to differences in air quality, hydrometeorologic conditions, and public works practices that characterize the study area. Since very detailed information on "land use-nonpoint pollution" relationships had previously been developed (3) for the Occoquan Basin, NVPDC decided that it would be appropriate to use available computer models to estimate the efficiency of structural BMP's under selected operating rules. It is felt that the BMP efficiency projections produced by these modeling studies can serve as reasonable planning estimates until local field data on BMP operations becomes available.

Since one of the objectives of the control measure study was to determine whether or not BMP's could realistically be substituted for restrictions on future urban development in the basin, land use controls were not evaluated with the Occoquan Basin Computer Model. Street-sweeping controls were also omitted from the modeling study since this BMP was felt to be unsuitable for large-scale applications in the basin's four counties where roadway maintenance is the responsibility of the State rather than the local governments. Although neither source control BMP is felt to be adequate for areawide application in the basin, both land use planning techniques and street-sweeping controls represent viable alternatives for supplementing the water quality benefits of areawide management programs that rely upon other urban BMP's.

To simplify the BMP evaluations and to assure that the BMP comparisons were uniform from one jurisdiction to the next, it was assumed that all structural BMP's would be of the "onsite" variety serving 40-acre watersheds with a homogeneous land use pattern. A

40-acre drainage area was utilized since this watershed size was relatively close to the average drainage area tributary to a series of onsite controls included in a recent study (16) of suburban stormwater management practices in the metropolitan Washington area. Each BMP strategy was simulated with NVPDC's STORAGE-TREATMENT submodel (17) which is operated in series with the NPS submodel (7) to approximate the major unit processes that remove pollutants from runoff waters passing through the BMP. For modeling studies of volume controls (e.g., Dutch drains, seepage pits) which have been utilized for several years in Occoquan Basin jurisdictions for "flooding/streambank erosion" management, it was assumed that pollutant removal rates achieved in the underlying soil profile due to filtration, adsorption, biological decay, and cation-exchange were equivalent to those defined for "land treatment" facilities (i.e., rapid infiltration technique) used for wastewater disposal (18). For modeling studies of detention basin BMP's, which are also used in the Occoquan Basin for runoff quantity management, the STORAGE-TREATMENT submodel was programmed to apply user-specified sediment "trap efficiencies" to runoff inflows in order to approximate solids settling processes. Modeling studies of stormwater treatment BMP's relied upon the STORAGE-TREATMENT submodel to simulate pollutant removal at rates reported for physical-chemical treatment plants.

No modifications to existing stormwater management design criteria are required to produce a multipurpose volume control which achieves both runoff quantity and water quality management benefits.

The detention basin BMP's were assumed to be characterized by relatively high detention times (e.g., 30-40 hrs for drawdown) for runoff from minor-to-moderate storm events, which are of greatest concern from a water quality management standpoint. Traditionally, detention ponds have been designed to operate as single-purpose facilities that achieve "peak shaving" benefits during flood-producing storms, but provide relatively low detention times during the majority of storms.* In order to assure that detention basins operate as multipurpose BMP's, traditional design criteria must be modified to achieve relatively low release rates and high detention times for minor-to-moderate storms and acceptable peak release rates for flood-producing storms. Design criteria that involve the use of either perforated riser pipes or subsurface drains to maintain low release rates for a nonpoint pollution management section of the detention basin and the use of storage above the nonpoint pollution management pool to control runoff from flood-producing storms have been recommended by NVPDC for use in the Occoquan River Basin. Sketches of multipurpose detention basin

* Local criteria for flooding/streambank erosion control generally produce detention basin release rates and storage capacities that can maintain post-development peak flow from a major storm event (e.g., storm with a 10-yr or 2-yr recurrence interval) at pre-development levels.

BMP's that rely upon a perforated riser and subsurface drains to maintain an acceptable detention time for the nonpoint pollution management pool are shown in Figures 2 and 3, respectively. Of the two outlet structures, the subsurface drain offers greater potential removal efficiencies since, in addition to achieving pollutant removal through solids settling processes within the detention basin, this approach should permit additional removal of dissolved pollutants and colloidal particles in the overlying soil through such natural processes as filtration, adsorption, and biological decay.

Since the nonpoint pollution management component of the multipurpose detention pond will use up capacity that, in the case of a single-purpose runoff quantity management facility, would otherwise be available to store runoff volumes produced later in the design storm, a multipurpose facility requires a greater storage capacity than would a single-purpose facility. Although it is difficult to generalize about the storage increases required to satisfy runoff quantity management criteria since storage requirements are influenced by the physical characteristics of each catchment, NVPDC studies indicate that a 10%-25% increase in storage will generally be required.

It was assumed that onsite stormwater treatment BMP's would consist of a detention basin with a flow-regulated chemical feed device. Such a facility would rely upon physical-chemical treatment processes to achieve high removal rates for suspended (i.e., colloidal particles) and dissolved pollutants which would not be removed in typical detention basin BMP's.

Cost estimates for each BMP strategy were based on unit cost data derived from literature values that were felt to reflect local conditions. Since volume and detention basin controls are currently used for runoff quantity management in Occoquan Basin jurisdictions, the cost-effectiveness analyses considered only those costs associated with modifying stormwater management facilities to achieve high levels of nonpoint pollution control. In the case of volume controls, no modifications to single-purpose designs (e.g., flooding/ streambank erosion controls) are required to achieve nonpoint pollution management benefits; consequently, there are no incremental costs associated with the transition from a single-purpose to a multipurpose volume control. In the case of detention basin controls, incremental costs associated with the transition from a single-purpose to a multipurpose facility cover the additional storage requirements associated with the provision of a nonpoint pollution management pool and increased maintenance requirements associated with the higher detention times and sedimentation rates. Incremental costs associated with stormwater treatment measures cover flow regulators, the chemical feed system, power, and residuals disposal requirements which are not common to single-purpose detention basins.

Computations of BMP strategy costs accounted for the timing of urban development during the 27-year planning period (1979-2005).

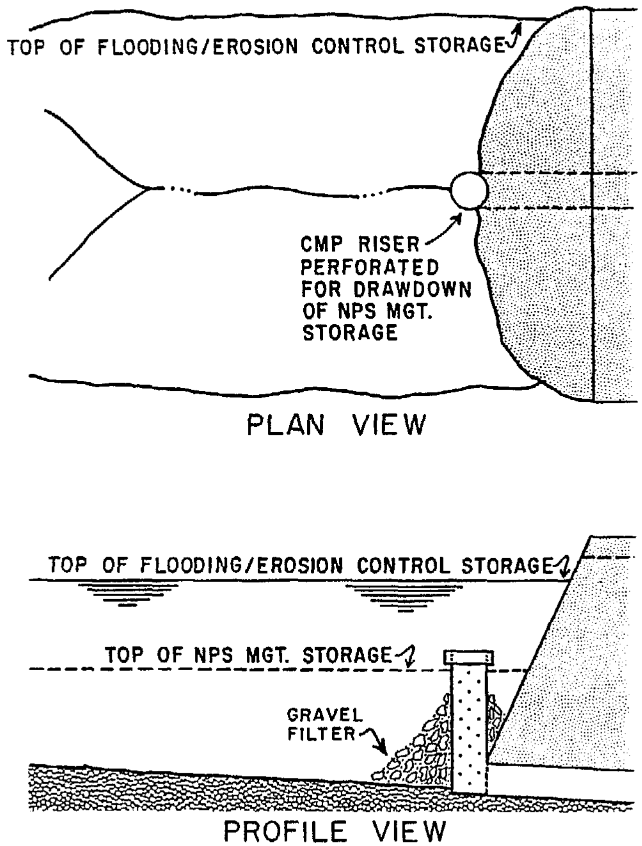


FIGURE 2. MULTIPURPOSE DETENTION BASIN BMP WITH PERFORATED RISER FOR NONPOINT POLLUTION MANAGEMENT

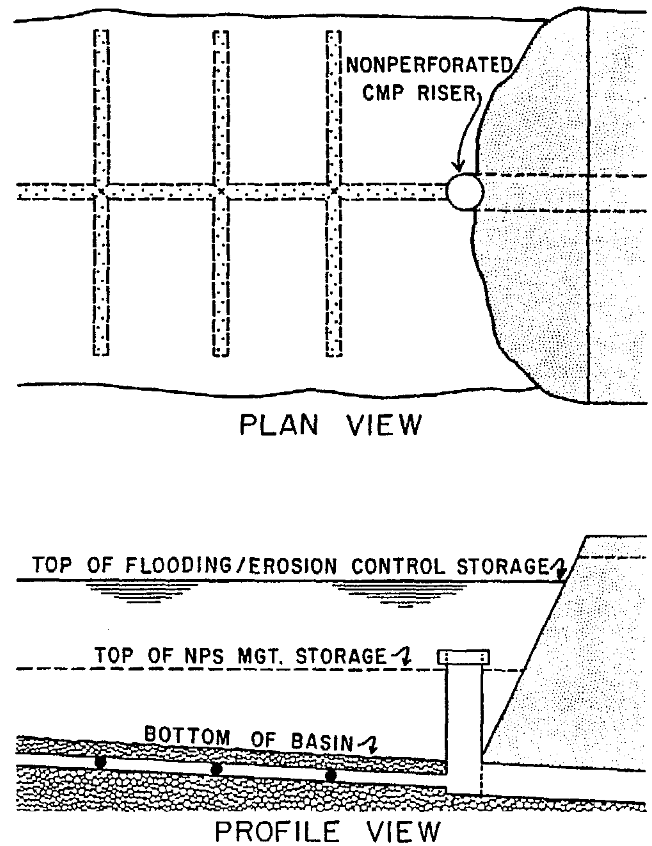


FIGURE 3. MULTIPURPOSE DETENTION BASIN BMP WITH SUBSURFACE DRAINS FOR NONPOINT POLLUTION MANAGEMENT

The rate of urban development was represented as a gradient series that increased at a uniform rate between 1979 and 1985, between 1986 and 1995, and between 1996 and 2005, and the rate of BMP implementation was based upon a linear approximation of basin growth rates within each time increment.

Cost-Effectiveness of Urban BMP Strategies. To derive a benchmark for assessments of urban BMP strategies, the Occoquan Basin Computer Model was used to compare the water quality impacts of existing and future land use patterns, assuming a year of average wetness and AWT discharges in accordance with the 1971 Occoquan Policy. The modeling study indicated that an uncontrolled Year 2005 land use pattern can be expected to produce a 16.1% increase in total phosphorus loadings delivered to the Occoquan Reservoir, a 5.3% increase in unoxidized nitrogen loadings, a 9.1% increase in total nitrogen loadings, a 15.0% increase in BOD loadings, and a 187.0% increase in lead loadings.

As previously indicated, separate model executions were carried out to characterize the benefits of each nonpoint pollution control strategy. Since the model runs assumed that these BMP's would only be applied to future urban development, BMP benefits are best viewed in terms of reductions in increased pollutant loadings associated with additional urbanization.

The modeling studies indicate that all three BMP strategies should be capable of reducing nonpoint pollution loadings from future urban development to levels that either approach or are lower than existing conditions. Stormwater treatment BMP's promise to achieve the greatest nonpoint pollution loading reductions for all pollutants, producing Year 2005 nonpoint pollution loadings which are generally lower than those associated with existing conditions. Annual nonpoint pollution loading reductions associated with stormwater treatment BMP's are 1.1-1.3 times greater than loading reductions associated with volume controls, with the greatest difference associated with total phosphorus and the smallest difference associated with BOD, and 1.3-1.9 times greater than loading reductions associated with detention basin BMP's. However, the "annual costs per lb removed" associated with the stormwater treatment strategy are quite high, as much as 12.3-18.9 times greater than the unit costs associated with detention basin BMP's. The disparity between unit costs for stormwater treatment and volume control BMP's is even greater since the latter controls require no additional expenditures over and above the costs required to achieve runoff quantity management objectives.

Cost-effectiveness comparisons were also developed for simulated receiving water quality indicators such as mean total phosphorus and chlorophyll a concentrations in the Occoquan Reservoir during the algal growing season. Alternative BMP's may be compared according to the "incremental cost per mg/l reduction" in ambient concentration of a particular constituent. The results of Occoquan Reservoir water quality comparisons are similar to the results of the pollutant loading comparisons. Since there are no incremental costs associated with the volume control BMP strategy which was projected to produce mean concentrations of phosphorus and chlorophyll a in the Occoquan Reservoir that approach existing conditions, it was concluded that this BMP is more cost-effective than either detention basin BMP's or stormwater treatment BMP's. "Costs per mg/l reduction" associated with the stormwater treatment BMP strategy, which is projected to produce Occoquan Reservoir water quality levels that are slightly better than existing conditions, are 13.4 times greater than the detention basin BMP strategy's unitcost in the case of mean epilimnetic total phosphorus during the algal growing season and 7.6 times greater in the case of mean chlorophyll a. Comparisons based on reductions in annual total phosphorus accumulations within the Occoquan Reservoir yield similar results: unit costs associated with stormwater treatment are 14.5 times greater than those associated with online detention, although reductions in total phosphorus accumulations are only 1.7 times greater. Since volume control BMP's and detention basin BMP's promise notable loading reductions and improvements in receiving water quality at unit costs which are considerably lower than those associated with stormwater treatment BMP's, it was concluded that these stormwater management practices represent the most cost-effective approach to managing nonpoint pollution from future urban development.

Summary. The conclusions which were drawn from the BMP modeling studies described herein are as follows: (a) traditional stormwater management techniques such as volume controls and detention basin controls (with modified design criteria) should be capable of maintaining Year 2005 nonpoint pollution loadings and ambient water quality at levels equivalent to or in the vicinity of existing conditions, in effect achieving nonpoint pollution management benefits that are reasonably close to those associated with land use controls which would minimize future development in the Occoquan Basin; (b) the adoption of traditional urban stormwater controls for nonpoint pollution management programs will involve only a 10%-20% increase in the total cost of a detention basin facility and no change in the total cost of a volume control facility; (c) although stormwater treatment BMP's promise to achieve the greatest reductions in nonpoint pollution loadings, the water quality benefits associated with this control measure do not appear to be great enough to offset its extremely high costs; (d) in light of (a), (b), and (c), traditional urban stormwater management BMP's appear to represent a much more cost-effective approach than urban stormwater treatment and a viable alternative to land use controls for the Occoquan Basin; and (e) in conjunction with the application of multipurpose stormwater management BMP's to future urban development, adoption of the following management practices can be expected to produce nonpoint pollution loadings and receiving water quality impacts which are even lower than existing conditions: land use planning and site planning procedures that account for nonpoint pollution impacts; voluntary implementation of BMP's (19) in rural-agricultural sections of the basin; and measures (e.g., street-sweeping programs in the basin's cities) that address nonpoint pollution loadings from existing urban development. As indicated below, the Occoquan Basin jurisdictions have established an areawide nonpoint pollution management program which includes all these ingredients.

Although the Occoquan Reservoir was the focus of the 208 planning study of urban BMP strategies, similar comparisons of BMP cost-effectiveness would be expected for other streams and reservoirs in the Occoquan River Basin. In other words, an urban nonpoint pollution management program for the Occoquan Basin will not only achieve regional benefits expressed in terms of the Occoquan Reservoir, but it will also achieve local benefits expressed in terms of water quality improvements in local streams and reservoirs.

Areawide Nonpoint Pollution Management Program

Introduction

Based on the conclusions of NVPDC's 208 planning study, the 208 plan (20) for the Occoquan River Basin provides for the establishment of an areawide nonpoint pollution management program to supplement the benefits of the Basin's wastewater management program. In striving to control water quality problems which are not addressed by wastewater treatment plants, the basinwide nonpoint pollution management program, has as its goal: (a) the implementation of the most cost-effective nonpoint pollution mitigation techniques during the early stages of urbanization, so as to minimize the risk of irreversible water quality degradation and/or the need for costly remedial control measures at some later date; and (b) the management of nonpoint pollution loadings from agricultural lands within the basin. The management program is strictly advisory in nature, and as such, it is primarily a vehicle for fostering interjurisdictional cooperation, for providing continuing technical assistance to local staffs, and for monitoring local progress in the area of nonpoint pollution management.

The areawide management program was established in November 1978. It is administered by a policy board which is advised by a special technical committee. Technical and administrative staff support for the management program is provided by NVPDC. The FY 1980 operating budget for nonpoint pollution management program activities is approximately $60,000.

Features of Areawide Program

Policy Board. The areawide nonpoint pollution management program is administered by the Occoquan Policy Board, whose membership includes representatives of the basin's six political subdivisions, the City of Alexandria, the Fairfax County Water Authority, and NVPDC. Either a member of its governing board or the chief administrative officer represents each jurisdiction and agency. NVPDC serves as secretariat of the Policy Board and its representative serves as non-voting chairman.

According to the provisions of the 208 plan, the Policy Board meets regularly to review local nonpoint pollution management activities, to monitor associated water quality changes with the Occoquan Basin Computer Model, to comment on the adequacy of local nonpoint pollution management efforts, to prepare quarterly reports summarizing local progress in the area of nonpoint pollution management, to review water quality data collected by monitoring agencies to determine if changes in basinwide water quality targets are warranted, and to adopt an annual operating budget for the areawide nonpoint pollution management program. The quarterly reports on local progress are forwarded to the governing boards of participating jurisdictions and agencies, the State Water Control Board, and the U.S. Environmental Protection Agency for review. It should be emphasized that all determinations by and recommendations of the Policy Board are strictly advisory and are not binding on any political subdivision participating in the areawide management program.

Technical Review Committee. The technical investigations that permit the Policy Board to formulate assessments of local progress in the area of nonpoint pollution management are conducted by an advisory committee known as the Technical Review Committee. It is composed of representatives of the planning and public works departments in each jurisdiction, representatives of local water/sewer authorities and rural-agricultural management agencies, a representative of the NVPDC staff, and one citizen representative from each participating jurisdiction. NVPDC serves as secretariat of the Technical Review Committee and its representative serves as non-voting chairman.

The Technical Review Committee meets prior to each Policy Board meeting to review nonpoint pollution projections developed with the Occoquan Basin Computer Model, to determine whether projected impacts are consistent with the basinwide water quality target, and to prepare draft quarterly reports for review and adoption by the Policy Board.

Basinwide Water Quality Target. The basinwide water quality target which has been established to gauge local progress in the area of nonpoint pollution management is minimal deterioration in surface water quality. The potential benefits of local nonpoint pollution management programs that minimize further deterioration of water quality in the Occoquan Reservoir and other critical surface waters are substantial, including:

(a) Increases in the useful life of the Occoquan Reservoir: The need to maintain the highest affordable levels of water quality in the Occoquan Reservoir has taken on a new dimension now that the Reservoir is being considered by the Corps of Engineers for inclusion in a metropolitan-wide raw water interconnection scheme involving either the Potomac River or Shenandoah River.

(b) Reductions in water treatment costs: Nonpoint pollution management programs that minimize further deterioration in water quality within the basin's impoundments can achieve reductions in algicide applications to reservoir surface waters, in chemical and power costs for taste and odor control during water treatment, and potentially, in capital and O&M expenditures for new treatment facilities to meet EPA's THM standard.

(c) Sustenance and propagation of diverse aquatic life: Nonpoint pollution management efforts that achieve reductions in the rate of eutrophication can prevent shifts to the less desirable fish species that can survive in highly eutrophic waters.

(d) Enhancement of water-based recreation opportunities: The 1979 "Virginia Outdoor Plan" prepared by the Commission of Outdoor Recreation indicates that Northern Virginia is particularly deficient in water-based recreation facilities to serve existing and future populations. Water quality benefits achieved by the nonpoint pollution management program should facilitate the expansion of water-based recreation opportunities within the Occoquan River Basin.

Local progress toward the water quality target will be measured on a quarterly basis with the Occoquan Basin Computer Model which has the capability to estimate jurisdictional contributions within multijurisdictional sub-basins. At some later date, after the participating jurisdictions have gained some experience with the areawide management program and additional modeling studies and field studies have been completed, it is anticipated that the establishment of local nonpoint pollution loading limits which ensure minimal water quality deterioration will receive serious consideration. The computer model would then be used to periodically compare current nonpoint pollution loads with local loading targets and to project changes in receiving water quality which can be expected to result from differences between current and target loads.

Occoquan Basin Computer Model. The core of the areawide nonpoint pollution management program is the Occoquan Basin Computer Model. The major benefit of a computer-based watershed model is that, once calibrated, its assessments of long-term receiving water impacts of proposed land use patterns and water quality management schemes can produce significant cost-savings by minimizing the need for approaches involving investments in conservative facility designs and lengthy monitoring periods to identify the most appropriate factor of safety. During NVPDC's 208 planning study, the computer model was used to evaluate the cost-effectiveness of generalized urban BMP strategies. During the areawide management program, it is being used to monitor the cumulative, multijurisdictional impacts of local nonpoint pollution management programs that include applications of urban and agricultural BMP's. The model will be updated on a quarterly basis to reflect urban development, urban BMP's, and agricultural BMP's implemented in the basin. Data on urban land use changes and BMP's will be tabulated by local staffs and submitted to NVPDC on a quarterly basis for incorporation into the computer model. Data on agricultural BMP's, which are being implemented on a voluntary basis with technical assistance from local soil and water conservation districts, local offices of the VPI&SU Extension Service, the USDA Agricultural Stabilization and Conservation Service, and the USDA Soil Conservation Service, will be periodically assembled by the respective management agencies and submitted to NVPDC.

Projections developed with the computer model will be used to document the achievements of local nonpoint pollution management programs for State and Federal regulatory agencies. Applications of the computer model are based on a design condition called an "average" year, which in many respects is equivalent to the "design storm" concept currently used for local stormwater management programs. It was felt that a year of average wetness represented a more realistic design condition than either a relatively "wet" or "dry" year. It is anticipated that the selection of a relatively wet year as the design condition might produce excessive levels of nonpoint pollution control, since nonpoint pollution management recommendations would be based on hydrometeorologic conditions which occur rather infrequently; in other words, BMP's based on wet year design conditions would probably provide unnecessarily high pollutant removal during years that are not characterized by high rainfall and streamflow volumes. By the same token, the selection of a relatively dry year as the design condition might produce nonpoint pollution management approaches that are incapable of minimizing further water quality deterioration during other hydrometeorologic conditions (e.g., average years and wet years) which can be expected to recur much more frequently than dry years. Thus, it was felt that the average year design condition would produce management recommendations which would be more cost-effective, in the long run, than those based on either wet or dry year conditions.

A recommended procedure for interfacing model applications with monitoring studies carried out by the Occoquan Watershed Monitoring Laboratory, the basin's water quality surveillance agency, has been derived for the areawide nonpoint pollution management program. Impacts of land use changes and BMP's are initially screened with the computer model to project cumulative impacts for the design condition, i.e., the average year. On at least an annual basis, water quality trends identified by these modeling studies will be compared with any trends identified during field studies in the basin. The results of the evaluations of water quality trends will be used to document local progress in the area of nonpoint pollution management and to determine whether or not revisions to the Program's water quality target and BMP strategies should be recommended.

The principal benefit of the computer modeling approach is that long-term basinwide impacts can be formulated for design conditions that facilitate the comparison of impacts from one year to the next. The projections developed by the model for the average year are assumed to be equivalent to the average impacts that would be defined by a 28-year field study (i.e., length of rainfall record which was used to identify the average year) of unaltered watershed conditions. Because field studies of receiving water quality have no control over the hydrometeorologic conditions that produce the monitored receiving water response, the evaluation of water quality management strategies must often await the accumulation of data over several years that cover an appropriate range of hydrometeorologic conditions. For example, field data collected during a series of relatively wet years may significantly underestimate the long-term water quality benefits of nonpoint pollution management efforts while data collected during a series of relatively dry years may produce substantial overestimates of the effectiveness of management efforts and of the long-term significance of uncontrolled nonpoint pollution loadings. The operation of a computer modeling program in tandem with basinwide field studies should expand the applications of short-term monitoring data and provide the necessary verification of model projections.

Advantages of the Selected Management Framework

One of the major advantages of the selected approach to areawide nonpoint pollution management is that it permits the participating local governments, rather than State regulatory agencies, to maintain maximum control over local nonpoint pollution management activities. At the time the approach was selected, it was felt that the initiation of a cooperative, advisory management program, which would be developed and controlled by local governments, would be preferable to postponing the implementation of local control programs until a management framework was dictated by State regulatory agencies. Through the use of planning tools such as the Occoquan Basin Computer Model, the participating local governments hope to be able to document sufficient local progress in the area of nonpoint pollution management to eliminate the need for State intervention at a later date.

The advisory approach selected for the Occoquan Basin nonpoint pollution management program also affords participating local governments with an extremely flexible tool for implementing an areawide program. As an advisory program, the selected management framework permits the basin's six jurisdictions to preserve local autonomy while jointly undertaking a nonpoint pollution management effort. Since the participating political subdivisions can easily maintain control over the manner in which the advisory management program evolves, it is viewed as a particularly appropriate nonpoint pollution management framework for an area where local governments are somewhat apprehensive about new regional programs. The ability to use staff from the existing regional planning agency (NVPDC) enhances the framework's attractiveness because it not only eliminates the need to create a separate agency to direct the day-to-day activities of the areawide management program but it also allows the participating jurisdictions and agencies to achieve significant economies-of-scale by pooling their resources to provide the annual budget for the program. In short, because it enables the multiple jurisdictions in the basin to effect a more gradual transition from local to regional environmental management approaches, the selected management framework would appear to offer fewer risks than more traditional institutions for areawide stormwater management such as a watershed improvement district or a soil and water conservation district.

Accomplishments to Date

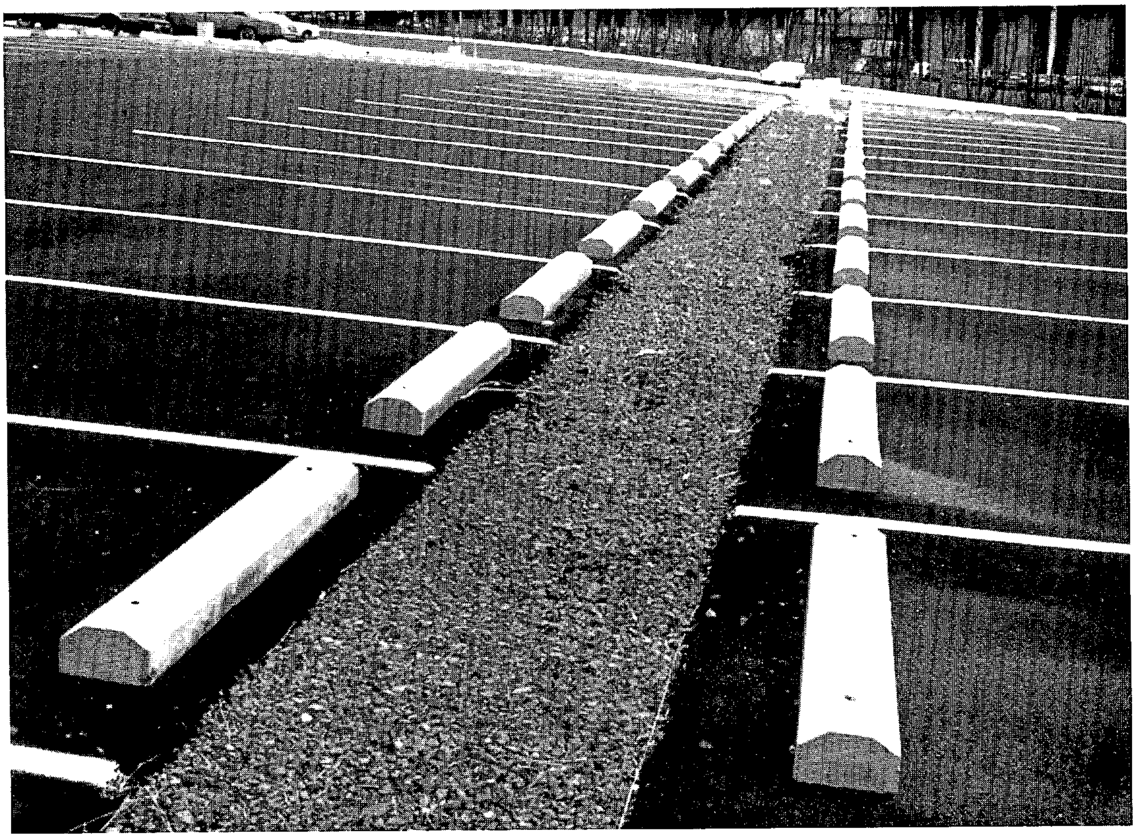
In the ten months that have passed since the areawide nonpoint pollution management program was begun, activities have focused on the development of nonpoint pollution planning tools for local staff applications. The NVPDC staff has formulated an Urban BMP Guidebook which outlines estimated BMP efficiencies and cost-effectiveness relationships for alternative design criteria. In addition, NVPDC has assisted local staff with the review of urban development proposals, the formulation of urban BMP recommendations, the evaluation of alternative local frameworks for nonpoint pollution management, and the identification of the most appropriate agricultural BMP's for the Occoquan River Basin.

Some jurisdictions have already made considerable progress in implementing nonpoint pollution controls. As indicated below, the Fairfax County Board of Supervisors has recently agreed to incorporate urban BMP requirements into the County Public Facilities Manual so that BMP's can be required for all new development that occurs in the Occoquan Basin, rather than limited to urban development proposals which qualify for rezoning review. Fauquier County has relied upon its subdivision regulations to require comprehensive BMP plans for several major single family developments; in addition, the County is constructing seven major flood control/water supply impoundments, which are funded by the U.S. Department of Agriculture's PL-566 program, that are projected to achieve substantial nonpoint pollution management benefits as well. The City of Manassas relies upon a vacuuum street-sweeping program which covers existing as well as new development. By late Fall 1979, it is anticipated that all participating jurisdictions will have selected an approach for institutionalizing urban nonpoint pollution management programs.

Local Management Framework: Fairfax County Case Study

Background

Fairfax County is a rectangular-shaped, 400 sq mi jurisdiction which lies southwest of Washington, D.C. Due to its proximity to the Nation's Capital, Fairfax County has been subjected to enormous growth pressures in recent years. A rural county of 40,000 in 1940, Fairfax is presently home for 600,000 suburbanites and still growing rapidly. The homebuilding industry has converted undeveloped land to low and medium density subdivisions to meet the



Gravel packed infiltration trenches at a Fairfax County shopping center achieve removal of suspended and dissolved pollutant loadings through natural processes in the underlying soil profile.

housing needs of these new residents.

Recently, urban development in the southwestern portion of the County has begun to alter the forested landscape of the 100 sq mi that is tributary to the Occoquan Reservoir. In 1957, the Occoquan Reservoir was constructed at the mouth of the Occoquan River Basin to provide a drinking water supply for much of Northern Virginia, including the majority of Fairfax County. In October 1967, ownership of the Reservoir was transferred to the Fairfax County Water Authority and the impoundment presently serves as the County's major water supply. At the time that the Reservoir was constructed, it was unlikely that anyone could have predicted that the growth of metropolitan Washington would generate significant urban development in the Occoquan River Basin, or that urbanization of the Basin could result in severe water quality problems. Nevertheless, these are precisely the issues that Fairfax County has to face as it attempts to develop reasonable measures to mitigate the nonpoint pollution problems associated with urban land uses in the Occoquan Basin.

Planning Protection for the Occoquan Reservoir

In the late 1960's, Fairfax County became aware that the Occoquan Reservoir had serious water quality problems. During this period advanced stages of eutrophication were observed. Since that time the County government through its professional staff has tried to develop strategies to protect the Occoquan Reservoir. Devising protection strategies has been difficult because the agencies with an interest in the Reservoir have disagreed on the causes of its eutrophic condition. During the last decade, professional opinion first implicated point sources as the principal contributor to Reservoir water quality problems. To reduce the point source contribution, Federal and local governments spent $82 million to build an AWT plant for the basin. More recent monitoring studies have suggested that nonpoint sources contribute the bulk of the pollutant loadings. These competing philosophies have complicated staff efforts to develop a pollution control strategy for Fairfax County.

Fairfax County has consistently made protection of the Occoquan Reservoir a high priority and has based many planning policies and development ordinances on the latest available water pollution control information. This has resulted in an evolutionary approach to water quality protection. As better data relating to the sources of and solutions to water quality problems in the Occoquan Basin have become available, the County has been able to refine its water quality protection strategy.

A full account of the evolution of County policies concerning the Occoquan Reservoir and River Basin is beyond the scope of this paper. It is sufficient to report that until NVPDC's 208 planning studies of the Occoquan Basin, staff had an inadequate information base to predict the water quality impacts of several crucial land use decisions. Staff recognized that existing land use policies and environmental regulations were inadequate to protect the Occoquan Reservoir.

The field studies and modeling analyses coordinated by NVDPC during the 208 planning program were the breakthrough County staff had hoped for. After years of speculation concerning the sources and impacts of nonpoint pollution, staff was finally provided with data on "land use-nonpoint pollution" relationships, BMP efficiencies, and Occoquan Basin water quality projections. As this data became more specific, recommendations were formulated. By December 1978, staff was able to apply this information to the environmental analysis of zoning cases.

In June 1979 staff made a presentation to the Board of Supervisors recommending that the County establish a policy requiring structural BMP's for all new development. The Board of Supervisors authorized staff to prepare appropriate revisions to the County's development regulations. Such a program may well be adopted and in place by January 1980. This event would be a milestone in the County's water quality protection efforts. Staff has been able to make such innovative recommendations with confidence because of the nonpoint pollution management planning tools produced by NVPDC's 208 planning studies.

The Evolution of a BMP Implementation Strategy

After searching for effective water quality protection measures for years, in the space of six months staff had progressed from making tentative BMP recommendations in selected rezoning applications to recommending a countywide program of BMP implementation.

The rapid development of Board of Supervisors support for BMP implementation was due to experiences in individual rezonings, the water quality concerns of individual Board members, the response of the development industry, and other factors. When staff first began to utilize the results of the 208 planning studies, no BMP implementation strategy existed. In retrospect, it is apparent that the course of events influenced the nature and timing of the implementation effort as much as any staff timetable.

The account of this six-month period is of course shaped by unique circumstances in Fairfax County. Nevertheless such an account has relevance to other urbanizing jurisdictions considering the implementation of urban BMP requirements. While the circumstances leading to implementation will vary, the lessons learned in Fairfax County indicate many of the problems a jurisdiction can be expected to encounter.

The Trifam Rezoning: A Case History. By the Fall of 1978, staff felt sufficiently comfortable with the nonpoint pollution management data developed by NVPDC to use it as an aid in individual zoning cases. The first rezoning affected, the Trifam case, was complicated by its impact on the Occoquan Basin's AWT plant which is operated by the Upper Occoquan Sewage Authority (UOSA).

Trifam Systems, Inc. sought to rezone 45 acres from the R-1 (1 du/ac) category to the R-8 (8 du/ac) category. The application met all of the County's normal requirements. The development plan "proffered" most of the conditions that County staff sought.* However, the property is located directly upstream from the AWT plant's "polishing pond," which is intended to serve as a final polishing process for treated effluent prior to release to the basin's receiving waters. Treated effluent that is discharged into the polishing pond is of high quality and generally considered to be suitable for use as an industrial water supply.

Shortly before the public hearing on the rezoning application, the UOSA Board wrote to the Planning Commission voicing its opposition to the rezoning application. A report prepared by UOSA's engineering consultant contended that nonpoint pollution loadings from this 45-acre site would degrade the water quality in the polishing pond, especially following major storms. The consultant estimated the amount and concentration of phosphorus washing off the Trifam site before and after development. Staff concurred with these findings regarding phosphorus runoff generation. However, the consultant's analysis was incomplete. No consideration was given to the impact of potential mitigation measures. Nor was the relative magnitude of this source of phosphorus compared to the entire nutrient budget of the polishing pond. The consultant did not present any analysis supporting its contention that the phosphorus generated on the Trifam site would lower the water quality of the pond.

By relying on the "land use-nonpoint pollution" generation relationships and BMP efficiency estimates provided by NVPDC, the County staff was able to estimate the pollutant washoff for the Trifam site and project the effectiveness of different combinations of BMP's at managing the nonpoint pollution loadings. Staff's analysis estimated average annual phosphorus washoff from the undeveloped site to be 9 lbs/yr. for a year of average rainfall. An R-1 development was estimated to produce 24 lbs. of phosphorus washoff per year. The projection for R-8 development was 46 lbs/yr. BMP assessments indicated that typical detention controls and volume controls should be capable of reducing washoff from the Trifam proposal (R-8) by 50%, to 23 lbs/yr. This is approximately the same phosphorus generation rate projected for a one unit per acre development (R-1) on this site. This is significant because

* The proffer system is a mechanism used to obtain specific commitments from rezoning applicants. Applicants proffer or agree to conditions that exceed zoning ordinance requirements before the case goes to public hearing. These proffers then become binding conditions. They cannot be required--the applicant must volunteer them. Once accepted and approved, the proffers are enforceable parts of the zoning ordinance for the affected parcels.

the site was already zoned R-1 as is most of the County's portion of the Occoquan Watershed. In other words, the Trifam developer was entitled to develop the 45-acre site at a density of one unit per acre simply by meeting the requirement of the subdivision ordinance. Since the County's subdivision requirements do not include BMP's, development at existing zoning with corresponding phosphorus generation levels is, in a sense, the developer's right. For this reason, staff viewed the R-1 level of phosphorus nonpoint pollution loadings (24 lbs/yr.) as a reasonable performance standard for more intense development on this site (21).

After careful consideration of the environmental characteristics of the site, a specific system of BMP's was recommended to the applicant by County staff. This recommendation consisted of a multipurpose detention pond designed in accordance with aforementioned criteria to facilitate sedimentation and a system of infiltration trenches on an area of permeable soils. BMP efficiency estimates were formulated for phosphorus, which is suspected to be the limiting nutrient for algal productivity in the AWT's polishing pond, and the proposed control measure scheme was shown to be capable of maintaining R-8 nonpoint pollution loadings at the R-1 performance standard. The BMP assessments demonstrated staff's position that the imposition of BMP's was an appropriate compromise between the position of Trifam Systems, Inc. and the Board of Directors of UOSA. Because staff's hypothetical BMP strategy indicated that the R-1 performance standard was economically achievable at the applicant's proposed density, the County's Office of Comprehensive Planning proposed this phosphorus performance standard as grounds for a recommendation of rezoning approval.

The County then contracted with NVPDC to evaluate the polishing pond impacts of R-8 development which satisfied the R-1 performance standard for nonpoint pollution loadings of phosphorus. A detailed computer model of the 180 million gallon AWT polishing pond and its 570-acre watershed was formulated to assess the impacts of nonpoint pollution loadings from an R-1 land use pattern. To asssure a "worst case" analysis, it was assumed that all undeveloped land (352 acres) in the watershed, including the 45-acre Trifam tract, was developed at the R-1 density. Applications of this submodel revealed that an 18 MGD AWT effluent would produce 95% of the total annual volume of water passing through the polishing pond during a year of average wetness, and therefore, the AWT would be expected to dominate ambient water quality conditions in the following manner (22): (a) for "zero discharge" conditions, the AWT plant's effluent should achieve significant dilution of nonpoint pollution loadings from the equivalent of R-1 development (i.e., R-8 development with BMP's) in the watershed; or (b) for discharge at effluent levels specified in the NPDES discharge permit (e.g., total phosphorus concentration of 0.1 mg/l as P), the AWT plant would, by far, be the dominant source of pollutant loadings and therefore would tend to overshadow nonpoint pollution contributions from the equivalent of R-1 development.

Following the nonpoint pollution studies by the County staff and NVPDC, the Board of Supervisors in March 1979 made the decision that endorsed this use of BMP's. Although stiff resistance to this rezoning remained, the Board was presented with a well developed staff analysis that documented the adequacy of BMP's as an environmental protection measure for this application. With its motion to rezone, Fairfax County tacitly endorsed the use of BMP's to mitigate urban nonpoint pollution.

Success in this case gave staff the confidence and precedent to seek "BMP proffers" from all rezoning applications in the Occoquan River Basin. The Board of Supervisors which had previously been concerned about the implications of growth in the Occoquan River Basin, found in BMP's an expedient solution to address the water quality implications of urban development.

Use of the Proffer Process for BMP Implementation. An immediate impact of the Trifam rezoning was the application of the proffer system to BMP implementation. Both the Board of Supervisors and staff assumed that BMP proffers could be obtained in future rezonings in the Occoquan River Basin, though the Board did not produce a formal policy statement at that time.

There were several rezoning applications in the basin in the spring of 1979. Staff requested a nonpoint pollution performance standard, based on annual phosphorus loadings in the first of these cases. The logic used to develop this recommendation was similar to the Trifam case. Utilizing the technical reports (3,17) produced by NVPDC for the Occoquan Basin 208 planning study, staff produced desktop estimates of annual phosphorus washoff for each rezoning. BMP efficiency estimates were used to determine a reasonable performance standard. Although this analysis seemed reasonable to staff, the developers resisted any performance standard. They argued that proffering to a performance standard amounted to "buying a pig in a poke." Staff was convinced that the cost associated with the addition of BMP's to existing stormwater management requirements were minor, for example, less than $100/dwelling unit on the average to convert single-purpose detention basins to multipurpose facilities (12). Unfortunately, staff was not able to convince the representatives of the building industry that this was an accurate estimate of incremental costs.

Industry spokesmen raised many objections to BMP implementation. Many of these objections demonstrated a lack of familiarity with BMP's. The developers were unwilling to submit to a new requirement when the cost and effort required were not well documented. Some of the objections raised were that:

- BMP efficiency data has never been verified in the field.
- Low density residential developments may not need BMP's.
- Virginia's State Water Control Board, authors of the State of Virginia's BMP Handbook (19), had recommended a "voluntary" program for statewide BMP implementation.

- Water quality benefits were not great enough to justify the cost of BMP's.

- Reliance on proffered rezonings meant that only those applicants whose property required a zoning action were subject to BMP's.

Staff saw little merit to these objections except for the argument against seeking BMP's through the proffer process. Two weaknesses were identified: 1) coverage would be spotty and inadequate since proffers could be applied only to developments that had not yet been rezoned--about 10% of the Occoquan River Basin; and 2) it was unfair to apply BMP requirements only to development which required rezoning.

After several of these rezonings, the proffer process proved itself to be an inappropriate means of BMP implementation. Considerable staff time was invested in developing a BMP strategy for each application and in negotiations with each applicant. Eventually one applicant refused to proffer any stormwater management controls that were not already specifically required by County ordinances.

BMP's and the Public Facilities Manual: A Regulatory Approach. After difficulties with the use of the proffer process had been identified and analyzed, staff decided that amending the County's *Public Facilities Manual* (23) to create a regulatory program for nonpoint pollution management was the most cost-effective water quality control strategy available to the County. Existing requirements for stormwater detention basins could be modified to require multipurpose facilities sized according to criteria suggested by the Occoquan Basin 208 planning study. Such structural controls, when coupled with site planning techniques that minimize nonpoint loadings, would be more effective and equitable than BMP proffers.

In arguing against BMP proffers, members of the development community had suggested that the County *Public Facilities Manual* was the proper place to establish requirements for BMP's instead of the proffer process in rezonings. Staff agreed with this suggestion. Equity and maximum effectiveness are best obtained by uniform ordinance requirements. However, it should be noted that the BMP proffer period served to introduce BMP concepts to both the public and private sectors and therefore, it is probably best viewed as a useful first step in the evolution of a local nonpoint pollution management framework.

The County *Public Facilities Manual* already contains extensive stormwater management requirements. The existing standards require post-development runoff peaks to be maintained at predevelopment levels for two-and ten-year design storms (23). Of the two primary structural means of stormwater management permitted by the *Public Facilities Manual*, one is already a BMP--infiltration trenches--and the other, detention basins, can be converted to a BMP with minor modifications. These two structural measures are expected to be the core of a Countywide BMP strategy.

As indicated in the earlier discussion of multipurpose BMP's, the revisions to traditional stormwater management criteria that would be required to make flooding/erosion control devices also function as BMP's are minor, and the initiation of a major new program is unnecessary. Instead, a few revisions to the existing stormwater management regulations are all that is required.

As previously noted, during the six months following the Trifam rezoning, staff opinion was moving away from dependence on BMP proffers in rezonings. At the same time NVPDC, through the Occoquan Basin nonpoint pollution management program, was producing the specific data necessary to establish the design modifications for stormwater detention structures. NVPDC recommended that local jurisdictions implement BMP's through modifications to existing stormwater management requirements.

On June 25, 1979, the Office of Comprehensive Planning made a presentation on the Status of BMP's to the Board of Supervisors. The Office recommended that Fairfax County proceed to implement BMP's countywide. Staff analysis indicated that BMP's, based on a revision of the stormwater management requirements of the Public Facilities Manual, were the most cost-effective means of protecting the surface waters of the Occoquan Basin, and meeting local and regional 208 planning goals for protecting other local streams and the Potomac River and Estuary.

The staff presentation to the Board of Supervisors focused on the urgency of BMP implementation, and the cost-effectiveness of the structural stormwater management approach. Staff believes that urban sources of nonpoint pollution present the greatest danger to Occoquan Basin water quality. As previously indicated, NVPDC's model projections suggest that in the absence of BMP's, continued urbanization will increase the severity of eutrophication in the Occoquan Reservoir. The stormwater management modifications that staff recommended should meet the local implementation goals for the Occoquan Basin Nonpoint Pollution Management Program, thereby protecting the Reservoir from further water quality degradation.

County staff considered the costs for collection and treatment of stormwater to be prohibitive. The price of inaction is also potentially very high. For instance, if Occoquan Reservoir water quality continues to decline, the water utility may be required to provide granular activated carbon treatment units at an estimated capital cost of $28 million. $82 million has already been spent constructing the UOSA AWT plant to control point sources of pollution in the Occoquan Basin. NVPDC's 208 planning study indicates that requiring BMP's on the 20,500 acres of new development projected to occur in the Fairfax County portion of the Occoquan watershed by the Year 2005 will result in a $1.9 million cost (1978 dollars) over and above the current Public Facilities Manual requirements. Expressed on a unit area basis, the incremental cost of BMP implementation averages only $91 per acre for the County's portion of the Occoquan River Basin (12).

A majority of the Board of Supervisors appeared to be persuaded by this presentation. The Board directed County staff to prepare recommendations for modifications to the Public Facilities Manual and return by January 1, 1980 for Board action. The Board could implement stormwater management BMP's at that time.

Prospects for the Future

Staff expects that BMP's will be required countywide in 1980. The program, if enacted, will require stormwater retention/detention structures to be either volume control or detention control BMP's. NVPDC will provide County staff with desktop screening procedures to estimate nonpoint pollution impacts of small projects. Computer model studies can be used to evaluate major land use decisions as was done for the Trifam rezoning. NVPDC, in its role as interjurisdictional program coordinator, will continually assess the impact of new development and BMP implementation on the Occoquan Reservoir and other surface waters in the basin.

It would be inaccurate to assume that Fairfax County is on the verge of the millenium in stormwater management. Many problems have not been resolved. For instance, what are the maintenance requirements for BMP's? Are there safety and liability problems associated with stormwater management ponds? Would larger, offsite control structures financed on a "pro rata" basis be desirable? Should BMP's be applied in areas of existing development? These questions suggest water quality considerations will be assessed, reevaluated and altered for many years.

Although many concerns remain, the problems of nonpoint pollution are being handled constructively due, in large measure, to the 208 planning studies conducted by NVPDC, and that agency's eagerness to assist Fairfax County and the basin's other local jurisdictions in developing BMP implementation programs.

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STREAM VALLEY AND FLOOD PLAIN MANAGEMENT IN MONTGOMERY COUNTY, MARYLAND

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Introduction

Stream valleys contain some of the most beautiful and interesting terrain in Montgomery County. They provide an invaluable habitat for many species of wildlife and contain a wide variety of flora. Certain streams contained within the stream valleys are capable of sustaining a reproducing population of brown trout. Much of the county's early history of settlement is recorded along the stream valleys. Historical sites, including mills and early residences, exist in the valleys and provide a link with the past.

The county is fortunate to have leaders both past and present who recognize the importance and significance of the stream valleys and have taken the initiative to protect them for the benefit of the citizens of and visitors to Montgomery County. The Maryland-National Capital Park and Planning Commission (M-NCPPC), a bi-county planning agency for Montgomery and Prince Georges Counties, has played a lead role in stream valley management with the institution of its stream valley park acquisition program.

There are various other county, state, and federal agencies involved in stream and stream valley management in Montgomery County and their contributions are recognized. However, the thrust of this paper is to describe the stream valley acquisition program of the M-NCPPC, how it evolved, and its present status and effectiveness.

Stream Valley Acquisition Program

Preservation and conservation of stream valleys in Montgomery County was established as an objective and became county policy with the establishment of the M-NCPPC back in 1927. Involved in all aspects of planning, the M-NCPPC has placed a strong priority on preservation and conservation. Stemming from this philosophy, the stream valley acquisition program evolved.

Goals and Objectives

Briefly stated, the goals and objectives of the program are to protect the integrity of the streams, preserve the natural and historic features found in stream valleys and flood plains, and minimize damage to personal property resulting from flood waters. In order to achieve these goals and objectives, the M-NCPPC set out to acquire, through either purchase or dedication, the streamside land of all major streams in Montgomery County.

Capper-Crampton Act

The stream valley acquisition program was given its initial impetus with the passage by the United States Congress of the Capper-Crampton Act in 1930. This Act provided up to $6,750,000 in grants to park authorities in Virginia and Maryland for the purchase and establishment of stream valley parks. The sponsors of this imaginative and farsighted legislation were Congressmen Louis Crampton of Maryland and R. Walton Moore of Virginia.

For some 30 years, until the 1960s, this Act provided more than one-third of all funding for the acquisition and development of stream valley parks within the Washington, D.C. area. Carried out in cooperation with various federal agencies, funding from the Act has resulted in the preservation of over 3,000 acres of parkland and open space along the major streams in Montgomery County.

The acquisition of stream valley parkland began in the southern county areas where urban development was proceeding at a rapid pace. Capper-Crampton funds were used to purchase land adjacent to Sligo Creek, Rock Creek, Little Falls, and Cabin John Creek. These creeks and others are shown in Figure 1 with stream valley park areas delineated. In certain areas adjacent to the older and densely populated areas, these stream valley parks often provided many of the recreational features that are now part of the local parks such as playgrounds, ballfields, tennis courts, stables, golf courses and other facilities. In addition, they provide scenic relief for the suburban areas.

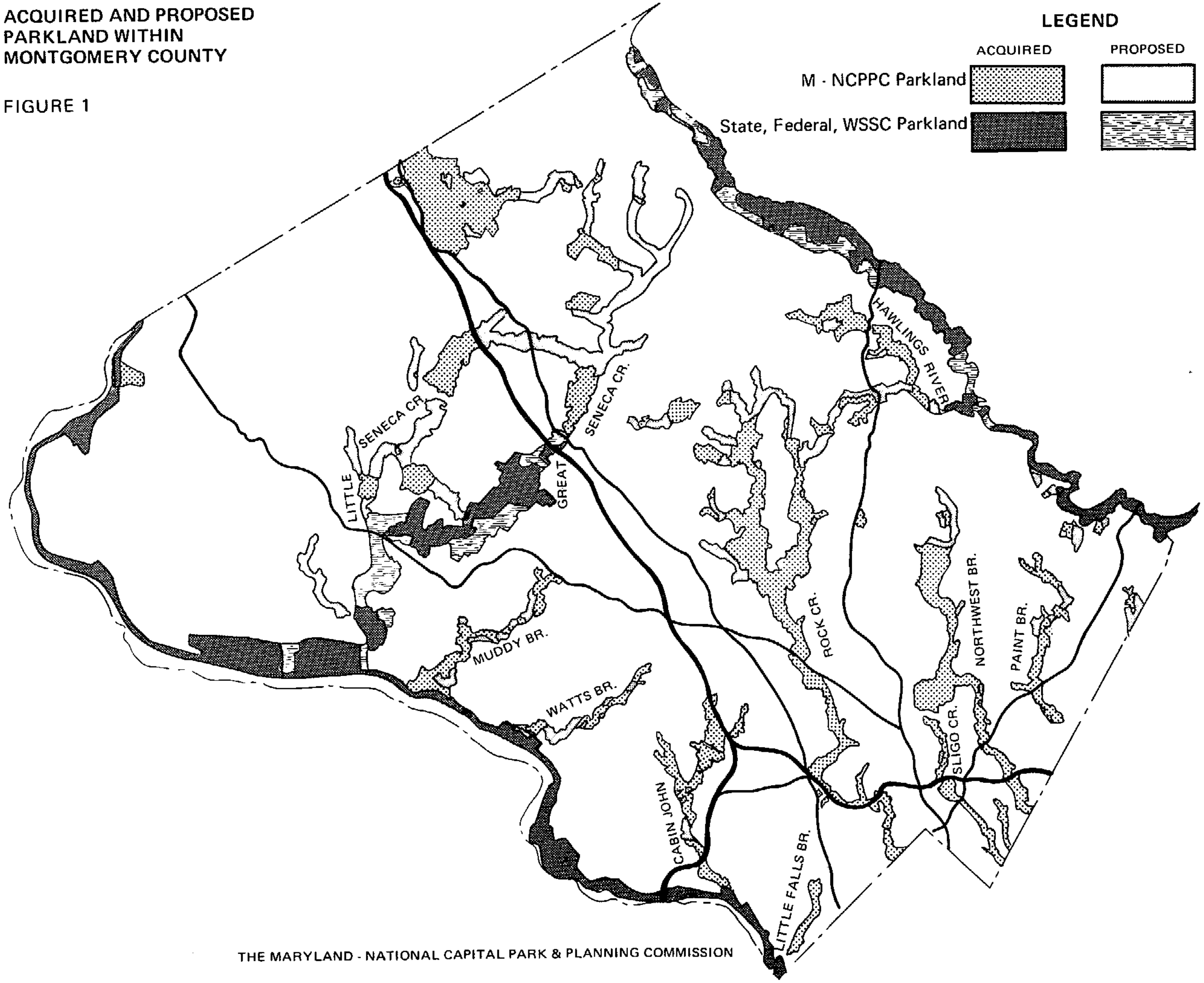
Status of Program Today

With the passage of time since the inception of the program and as new insight and awareness of the fragile nature of our environment has developed, the program has taken on an even more meaningful importance, namely that of protection and conservation of our valuable natural resources.

As stated previously, a large proportion of the land purchased by the M-NCPPC during the first 30 years was with funds provided by the Capper-Crampton Act. Since then, however, the program has maintained its momentum with the acquisition of lands in many other stream valleys. These include Watts Branch, Muddy Branch, Little Seneca Creek, Great Seneca Creek, and Hawlings River (see Figure 1). As of the present, some 10,500 acres of stream valley and flood plain lands have been acquired through the program. Ultimately, about 17,500 total

ACQUIRED AND PROPOSED PARKLAND WITHIN MONTGOMERY COUNTY

FIGURE 1



acres will be acquired and brought into the public domain (1).

Funds used to purchase and develop stream valley parks have been derived from various sources. Besides the Capper-Crampton funds, during the 1960s and early 1970s funds were obtained under the Federal Open Space Act. The M-NCPPC was the first agency to receive a grant for the purchase of stream valleys under this Act. The Patuxent River Watershed Act provided funds for purchase of lands in the Hawlings River watershed. More recently, Program Open Space, funded by the State of Maryland, has provided limited funds to assist in the stream valley acquisition program. However, the current policy is to use these funds primarily for local park acquisition. The major source of funds for the purchase of stream valleys and park development is through Montgomery County bonds.

Park Taking Lines

In order to identify and delineate those areas to be included in the acquisition program, park taking lines are established by the M-NCPPC and approved by the Montgomery County Council. These lines are not established arbitrarily; a detailed and systematic analysis is conducted by the M-NCPPC in order to establish the appropriate taking lines. The major factors considered are:

1. The 100-year flood plain. The 100-year flood plain is the land that would be inundated by a major flood that has a one percent chance of occurring in any given year. The M-NCPPC uses the 100-year flood plain associated with the ultimate planned land use in the watersheds as the minimum for inclusion within the park taking lines.

2. Vegetative cover. To preserve woodlands or other exceptional types of vegetation located adjacent to the stream, these areas are consideed for inclusion within the park as they add to the natural beauty of the park and provide opportunities for nature study.

3. Steep slopes. Slopes over 15 percent located adjacent to the flood plain are generally included within the park taking lines because they are an important part of the stream valley, generally wooded, critical for erosion control, and provide excellent opportunities for variety in hiking.

4. Ridge line. Park acquisition to include the ridge line is considered to take maximum advantage of scenic views both into and out of stream valleys.

5. Historic sites. An evaluation of historic sites within close proximity to the stream valley is made to determine if the park taking lines should be extended to include them for preservation.

6. Unique natural features. As with historic sites, unique natural features (i.e., areas termed "environmentally

sensitive") are evaluated to determine if they are important enough to be included within the park.

7. Property boundaries and improvements. To make acquisition less difficult, park taking lines are drawn to coincide with property lines where feasible. Because of the cost of improvements and the difficulties of relocation, park taking lines are drawn to exclude houses and other improvements where the property is not essential to the park.

8. Linkages for path systems. Park taking lines within stream valleys may be extended to form linkages within or between all types of parks and subdivisions so that a more integrated hiker and/or biker path system may be achieved.

9. Proposed reservoirs. The inclusion of land needed for proposed reservoirs (to include land to be inundated plus land needed for recreation and buffering) is considered when park taking lines are drawn.

10. Local park needs. Where a need for a local park is determined within a stream valley, the park taking lines may be extended to include these areas as a portion of the stream valley park system. This would also be true of special recreational facilities such as archery or shooting ranges, riding stables, educational nature facilities, or any other recreational use that is well suited to stream valleys.

11. Land costs and budget limitations. The cost of land and the amount of monies that can be made available for stream valley acquisition is an important determinant of the amount of land that can be acquired outside of the flood plain and the extent of the stream valley park system.

These factors represent the most desirable delineation of park taking lines. Practical budget constraints are the final determinant, however, and a compromise must sometimes be reached to stay within budget limitations.

Information on the factors used to establish the park taking lines is derived from many sources, the most important being from comprehensive watershed studies. Recognizing that certain changes resulting from urbanization within Montgomery County would be detrimental to the streams, the County Council appointed a stormwater management task force. The task force recommended that countywide stormwater management should be considered and adopted as part of the General Plan and that a stormwater management plan should be developed for each watershed within the County. Since that time, the M-NCPPC, under the direction of the Montgomery County Planning Board, has been engaged in developing Master Plans for each major watershed within the County.

In 1974, the M-NCPPC retained the firm of CH2M HILL to conduct technical watershed studies. Studies and plans have been completed for the Seneca Creek, Muddy Branch and Rock Creek watersheds, which comprise some 200 square miles. A state-of-the-art hydrologic simulation model has been utilized to analyze the quantity and quality of stormwater runoff for the existing and planned ultimate land use conditions. As part of the studies, water surface profiles are computed using the U.S. Army Corps of Engineers Water Surface Profile Program, HEC-2. Based upon the profile computations, the 100-year flood plains are determined and delineated on topographic maps. In addition to the flood plain maps, the studies identify historical sites, environmentally sensitive areas, and other features within the stream valleys that should be considered for preservation. The M-NCPPC presently has studies underway in six other watersheds.

Effectiveness of the Acquisition Program

One of the obvious benefits of the stream valley acquisition program is that, in maintaining the stream valleys and floodplains in parks and open space, development (building) in flood prone areas is held to a minimum. Hence, when severe flooding occurs, property damage is relatively small. This was evidenced by flooding caused by two major storms within the past decade, Hurricanes Agnes and Eloise. Heavy property damage was suffered in adjacent and similarly populated areas of Pennsylvania and Virginia. In Montgomery County, losses were relatively small. This was due primarily to sparse development in the flood prone areas and is a tribute to the stream valley acquisition program.

By limiting or preventing intensive development adjacent to stream channels, stream degradation has been greatly reduced. Vegetation that shades the stream and maintains water temperatures suitable for sustaining fish species has remained untouched. This same stream valley vegetation, in the less accessible park areas, provides the habitat for many indigenous wildlife species (2). The stream valley parks are proving to be an effective deterrent to encroachment into environmentally sensitive areas. Thus, the goals set for the program to aid in maintaining the environmental integrity of the streams in Montgomery County are being realized.

As effective as the acquisition program is, it cannot by itself maintain and preserve the environmental integrity of the streams. Sources of pollution and sediment originating from outside the stream valley parks must be controlled. The Montgomery County Department of Environmental Planning (DEP), in conjunction with the Montgomery County Soil Conservation District (MCSCD), has instituted effective programs for the control of erosion and sedimentation. The primary target of their programs is the control of erosion and sedimentation resulting from construction activities. Control of pollution must be effected through strict control of point source discharges and institution of Best Management Practices to mitigate the nonpoint sources of pollution.

Conclusions

The program of stream valley acquisition initiated by the M-NCPPC and given impetus with the passage of the Capper-Crampton Act of 1930 has not only been effective in meeting its original goals, but has become an integral part of the total watershed management planning in Montgomery County. The system of stream valley parks and dedicated open space not only provides recreation and nature study opportunities, but also provides much needed scenic relief in the urban areas. Furthermore, the program supplements the goals of many of the ongoing Federal programs such as the Water Quality Control Act (PL 92-500), the Watershed Protection and Flood Prevention Act (PL 566) and the Flood Disaster Protection Act.

The benefits derived by our generation and generations to come from the Stream Valley Park program stand as a tribute to the past and present leadership in Montgomery County that has instituted and sustained the program.

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ACHIEVING LOCAL SUPPORT FOR SURFACE RUNOFF MANAGEMENT IN THE SAN FRANCISCO BAY AREA

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INTRODUCTION

As a part of the initial areawide water quality ("208") planning effort, the Association of Bay Area Governments (ABAG) developed a planning process for the preparation of a regional surface runoff management plan. The plan was adopted by the local governments in June, 1978, and was approved by the U.S. Environmental Protection Agency with conditions in February, 1979.

Since the plan's adoption, more than 90 management agreements have been secured by ABAG (including agreements from 73 of 84 cities and eight out of nine counties) to implement control measures in the regional plan. (1) ABAG's unique approach to local participation was largely responsible for the receptivity of local agencies and has since been emulated by other "208" agencies.

This paper begins with an historical perspective on water quality planning in California and the Bay Area. Then a brief outline is given of the organization of ABAG's overall "208" program, which involved extensive participation by elected officials, local agencies, special interest groups and citizens. The largest sub-section of this "208" program--development of county surface runoff management plans--is described next. Preparation of these plans by local agencies under the guidance of ABAG represented a new approach in developing water quality planning capabilities at the local level. Since the local agencies were actively involved in the data collection, problem identification and control measure development, an implementable plan was thus assured.

Following this detailed discussion of the surface runoff program, an overview of the public participation program is presented. The extensive regional and local public participation programs conducted by ABAG and the local agencies are described. These programs included advisory committee meetings, briefing sessions, public presentations, roundtable discussions, workshops, extensive mailing of plan progress reports and highlights, and a series of formal public hearings. Through these various means, the public was kept informed on the key issues and encouraged to participate in the planning process.

The final section of the paper describes the continuing local involvement in water quality planning. The successes of the initial program are summarized and the 1979-80 work plan is briefly described. The paper concludes with a recommendation for the future of the program.

HISTORY OF WATER QUALITY PLANNING IN THE BAY AREA

Water quality planning in California and the San Francisco Bay Area has not traditionally involved active participation of local governments. It has, instead, tended to follow a "top-down" approach. A single-purpose agency would be designated to prepare a plan. This agency would develop the plan unilaterally, usually with the help of consultants. The plan would usually require local agencies to implement it. Since these agencies had not participated in the plan development, they were naturally distrustful and were not motivated to cooperate in putting the plan into effect.

The San Francisco Bay-Delta or Kaiser Study is a good example of such aborted planning. (2) In 1965 the California Legislature authorized a study of the effects of waste discharges on San Francisco Bay and the San Joaquin Delta and the development of a comprehensive plan to control water pollution. The study considered a number of alternatives for controlling point source pollution. The alternative selected involved eliminating discharges to the Bay and conveying most of the wastewater to the Pacific Ocean. The creation of a regional planning and operating agency was recommended to implement the program. The State Legislature failed to pass a bill forming such an agency. Without a suitable operating agency having regional authority, implementation of the plan became impossible. Local agencies had been excluded from the planning process and this $2 million study was put on the shelf. (3)

A second major Bay Area water quality planning effort was begun in the early 1970's. Known as the San Francisco Bay Area Water Quality Control Plan or Basin Plan, the study was conducted to comply with the provisions of the State Porter-Cologne Water Quality Control Act and the Federal Water Pollution Control Act Amendments of 1972. (4) As was the case with the previous Bay-Delta Plan, the Basin Plan emphasized point sources of water pollution.

The Basin Plan was prepared by the Regional Water Quality Control Board (RWQCB) using a consortium of engineering consulting firms. Aware of the fate of the Bay-Delta Plan, the basin planners decided on a different approach. Rather than develop a plan that would have to be implemented by a new "super" agency, it was decided that the new plan must be acceptable to and implementable by existing agencies whenever possible.

The basin planners were aided by the results of twelve subregional planning studies that were conducted between 1970 and 1973, after publication of the Bay-Delta study. Many local sewerage agencies, although critical of the large-scale consolidation proposed in that study, had agreed that some degree of consolidation was economically advantageous. These agencies then signed joint-powers agreements to study the feasibility of bi-county or multi-city consolidation. The result of these studies formed the basis of the Basin Plan. (5)

BAY AREA "208" PLANNING

The task of preparing the Basin Plan was an easier one than the task of preparing a "208" plan three years later. The basin planners' job was to prepare a plan which set water quality objectives and waste discharge requirements for San Francisco Bay and the waters of the bay basin. The job of determining how to achieve these objectives was not part of the Basin Plan. The RWQCB is an enforcement agency; it has the authority to assure compliance with water quality standards and objectives. The "how to" part of the process was left to the waste dischargers.

The mandate of the "208" program was quite different. Section 208 of the Federal Water Pollution Control Act Amendments of 1972 called for comprehensive areawide planning for water quality management. The U.S. Environmental Protection Agency made it quite clear from the outset of the program that it wanted implementable plans.

The Association of Bay Area Governments became the designated "208" planning agency in the San Francisco Bay Area early in 1976. ABAG is a voluntary association of cities and counties. Its nine-county area encompasses about 7,000 square miles and 5,000,000 inhabitants - roughly the size and population of the state of Massachusetts. In 1976, ABAG's membership consisted of 7 of 9 counties and 87 of 93 cities.

The "208" plan for the Bay Area was part of a much broader plan called the Environmental Management Plan (EMP). It included not only a Water Quality Management Plan (WQMP), but also an Air Quality Maintenance Plan, a Solid Waste Plan and a Water Conservation, Supply and Reuse Plan.

The staff at ABAG decided that to assure success of the EMP, a high degree of local involvement would be the cornerstone of its program. This local involvement was to consist of:

- local elected officials
- local agency staff
- special interest groups, and
- private citizens

The first major decision made was to set up the Environmental Management Task Force (EMTF). The EMTF was a 45-member steering committee established to oversee the preparation of the "208" plan. The EMTF was composed of public officials (county supervisors, mayors, city councilmembers) and representatives of regional agencies, industry, labor and special interest groups (such as the Sierra Club, League of Women Voters, and minority organizations).

In addition, ten technical advisory committees and four policy sub-committees of EMTF were established to advise staff and the Task Force and to review analyses and proposals before they appeared in draft plan form. These committees typically were composed of 30-50 members, including representatives of industry, labor, environmental and other special interest groups, elected officials and staff from local, regional, state and federal agencies. (The activities of EMTF and the comittees are discussed further under the section heading The Public Participation Program.)

THE SURFACE RUNOFF PROGRAM

Of the four plans making up the EMP, the one with the highest degree of local involvement was the Water Quality Management Plan. The WQMP was divided into two parts -- a point source portion and a nonpoint source portion. Point sources had been dealt with extensively in the Basin Plan and the subregional plans. The mandate of Section 208 planning was somewhat broader than what was called for under California's Water Quality Control Act, but most of the major point source controls had already been planned. A few remaining issues needed to be addressed, such as the 20-year project list, vessel wastes and oil spills, but the bulk of the work had already been done.

The situation regarding surface runoff was quite different. No surface runoff planinng had ever been done in the region and little had been done to control the problem. In fact, when the program started, very few people (including elected officials and local agency staff) even knew what surface runoff was.

Aware of EPA's strong desire for implementability and of the failures of past water quality planning efforts, ABAG decided to involve local governments in plan development. The involvement was to be much more than tokenism. Local agencies were to be given the responsibility for preparing their own plans. It was felt that only by giving local government this responsibility would the plan be implemented. The funding would be passed through ABAG directly to local agencies. ABAG would coordinate the effort to ensure consistency and comprehensiveness.

County Participation

The next question was: which local agencies should prepare the plans? Trying to manage 93 cities would be too unwieldly. Counties seemed the logical choice. There are 9 counties in the region -- a manageable number. Also, counties have closer ties to their cities than ABAG, and thus would be an effective liaison.

The county administrators in each of the region's counties were contacted. The counties were asked to select a lead agency to prepare a surface runoff plan under contract to ABAG.

Of the nine counties, eight were eventually put under contract. San Francisco County choose not to participate because it felt that it already had a surface runoff plan -- a $1.2 billion program to treat both its stormwater runoff and sewage in a combined system. The price tag on the system is now $1.9 billion and there is now some controversy over whether the residents of San Francisco are willing to pay for their portion of it.

The eight counties that chose to participate had various reasons for doing so. Only two were initially enthusiastic about participating; these counties seemed genuinely pleased that they now had a chance to study some problems that they never had funding to study before "208." The majority of the counties seemed to have joined the program in reluctant acceptance of the fact that surface runoff plans would be prepared whether they had a part in them or not. These counties apparently felt that if they did not prepare the plans, the State or EPA would do it for them. This alternative was less desirable than active paticipation. One county could not decide whether to take part in the program or not. Later it decided to poll its cities to get their reaction. When many of the cities expressed an interest, the county finally decided to participate. This county signed a contract about six months into the two-year program.

Managing County Surface Runoff Planning

The task of preparing a coordinated set of eight surface runoff plans was not easy. The director of the program, a former consultant, later described the process as "trying to set up a consulting firm with eight branch offices at the same time."

The agency selected by the county administrator to prepare the county plan was typically the flood control district or water agency. In some counties it was the planning department or a joint effort of both planning and public works. (6) Most of these agencies had not dealt with water quality before. Thus, water quality training was required.

Before the technical aspects of the program could begin, an organizational structure had to be devised. The counties were adding a new program onto an existing administrative structure that was not set up to handle it. Some counties chose to assign "208" responsibilities to existing staff along with their regular work load. Other counties hired a "208" coordinator to develop the surface runoff plan. Some counties hired consultants to assist them. At the end of the program, those counties which had hired a new person and assigned surface runoff as that person's main responsibility produced the best plans. The task of preparing a surface runoff plan was too complex and too difficult to be squeezed into the workload of a current staff member.

To facilitate coordination of the work, ABAG staff requested the counties to furnish ABAG with an organization chart showing how "208" fit into the overall organization. The purpose of this chart was to identify key personnel, responsibilities and lines of authority. ABAG was thus able to communicate more effectively with key local staff members. The chart also forced the counties to formalize their internal organization and establish and clarify responsibilities of their personnel. (7)

The Regional Surface Runoff Committee

The county surface runoff program was coordinated by two ABAG staff members. As a management tool, a two-part committee was formed early in the program -- a working group and an advisory group. The working group was composed of one or two key staff members from each county and representatives from EPA, the Regional Water Quality Control Board and the State Water Resources Control Board. The county members were those responsible for preparing the plans. This group was convened on approximately a monthly basis to:

- discuss work progress
- compare data and interim products among counties
- make future task assignments and
- present current regulatory and legislative information from the regional, state and federal agencies.

As mentioned earlier, the county participants were not all initially positive about the products they were being asked to produce. Many difficult questions were raised at these working group meetings and there were some heated debates. The most serious concern was that surface runoff pollution problems (particularly the impact of polluted runoff on San Francisco Bay) were not sufficiently documented to justify taking corrective action. After Proposition 13 passed in California, local governments became even more concerned about spending local funds to solve problems that were not well documented.

A major side benefit of these working group meetings was their effectiveness in prodding members who were lagging behind in their progress to catch up. This was accomplished through peer pressure. Counties which were progressing well would present their status reports first. Then the others would be called upon. The effect was greater than any punitive measure would have been. Another disciplinary technique was to prepare progress reports with a section set aside for each county. If a county had not submitted its material, that part of the report would be blank. When these reports later began to be presented to the EMTF, composed of elected officials from each county, the county staff had even greater incentive to produce.

The advisory portion of the committee was a non-voting body which was advisory to the ABAG staff. Invitations to participate were sent to over 100 organizations and individuals, including:

- o industries with major water pollutant discharges
- o labor groups
- o environmental groups
- o governmental agencies (such as the State Department of Fish and Game and the Bay Conservation and Development Commission)
- o university professors
- o community and civic organizations, such as the League of Women Voters. (8)

Each organization was asked to select a representative to participate. About 50 persons agreed to serve. Prior to each meeting, ABAG produced agenda packets containing interim products and items for discussion. However, as time went on and it came time for substantive comments, advisory committee participation dwindled. One notable exception was the Council of Bay Area Resource Conservation Districts. This group maintained active involvement throughout the program and was later put under contract to perform part of the work. In the 1979-80 Work Program currently underway, the Council has been given a major role.

In contrast to the advisory group, interest in the working group meetings remained high and attendance consistently ran close to 100%. Meetings were characterized by lively debates between the counties and the regional, state and federal agencies. The regulatory agencies were made well aware of the concerns of local government. ABAG tended to serve the role of middle-man or mediator at these meetings.

County Committees

Similar to the regional surface runoff committees were the county technical advisory committees (TACs). Each county was asked to set up a local committee composed of representatives of cities and other county agencies. The purpose of these committees was to present local surface runoff planning issues to agencies within the county, particularly those agencies which could likely be designated as implementing agencies in the county plans.

County surface runoff staffs held periodic TAC meetings with their respective committees. Some went further and held additional public meetings. These public meetings typically served to introduce citizens to surface runoff pollution issues, to present possible solutions and to solicit audience comments. One county developed an animated slide show to aid their public presentations. Other counties took pictures of typical problem areas and organized slide presentations around them.

The combination of regional and local advisory committee meetings and public presentations was effective in giving affected agencies an early indication of their expected roles in implementing the plans.

Technical Support

Once counties had hired or assigned personnel to the program, training could begin. A wide variety of techniques were employed by ABAG to communicate technical information. These techniques included:

- o technical memoranda
- o workshops and conferences
- o meetings with individual counties
- o handbooks, papers, research publications, regulations and other documents
- o progress reports, maps, data compilations, letters and memoranda
- o telephone contacts

Each of these techniques was used extensively throughout the program. No single one of them was sufficient in itself, but in combination they worked very effectively. The technique of distributing to all counties noteworthy products or ideas from a participating county also proved very successful.

The first decision made regarding information transferral was to produce a series of technical memoranda. These memoranda were prepared according to a standard format and printed in large quantities for wide distribution. They were designed to provide the counties with specific information to support each phase of the work.

The first technical memorandum was devoted to the subject of setting up a water quality sampling program. Information was given on:

- o parameters to monitor
- o monitoring equipment
- o sampling technique
- o finding a lab to analyze samples
- o costs for lab analysis
- o references for additional information. (9)

Later technical memoranda covered:

- o developing base maps
- o selecting demonstration watersheds for water quality modeling
- o water quality criteria and standards for analyzing monitoring and modeling results
- o ranking water quality problems
- o preparing a surface runoff plan
- o developing a work program for continuing planning.

Workshops

The technical memoranda were just a small part of the training program. Probably the most effective training tools were the workshops. A series of eight workshops was held during the initial two-year program. These workshops were intensive one-day training sessions on three topics:

- o water quality monitoring
- o water quality modeling
- o surface runoff control measures. (10)

At the monitoring workshops, sampling equipment and techniques were demonstrated by experienced U.S. Geological Survey personnel and others. A field trip was taken to a monitoring site to demonstrate sampling techniques on an actual stream. Handouts were distributed at the workshops covering all material presented. These were provided in a loose-leaf binder so that additional materials could be easily added as they were produced. Loose-leaf binders were also provided for the modeling and control measure workshops.

A decision was made at the beginning of the program to perform a regional evaluation of surface pollution, using computer models. Each county was responsible for developing the data to apply the models to its jurisdictions. ABAG would provide the training in model set-up and operation, but county personnel would run the models. (11)

This hands-on approach to the modeling analysis was proposed to give the counties an on-going tool for water quality planning. It was felt that if county staff members were taught how to run the models, they would be more likely to use them for analysis of future projects. This hypothesis was proven when some of the counties acquired computer terminals of their own and ran the models after completion of the initial plans.

The task of training the various county staffs, most of whom had no prior computer experience, was a great one. The first modeling workshop presented an overview of modeling and described the information necessary for model set-up. A simple questionnaire was distributed to the counties, requesting the information necessary for model input. ABAG staff members and consultants then met with each county individually to assist them in filling out the questionnaires, delineating watershed boundaries and preparing all other necessary data inputs.

This was a slow, painstaking process requiring many hours of one-to-one assistance. Furnishing seemingly simple "how-to-do-it" cookbooks for setting up and operating models does not work by itself. Many patient hours of follow-up were required on a county-by-county basis.

After the counties had started their data preparation, a second modeling workshop was held to demonstrate various modeling techniques. Model applications from past water quality studies were presented, along with examples of how to test control measures using models.

A third workshop demonstrated the use of remote terminals connected to ABAG's computer system. Data developed by two counties and stored on ABAG's computer was accessed and run for observers. Then county personnel were given step-by-step instructions on how to store and access their data and run the models from their own terminals.

Following this model user's workshop, some counties began to run the models on their own. Others contacted ABAG to set up appointments to run the models using the terminals in ABAG offices. Within a few months, seven of the eight counties successfully ran the models using three sets of land use projections and up to 25 years of rainfall data. (12)

When the data from the year's monitoring program was compiled and analyzed, a third monitoring workshop was held. The purpose of this workshop was to compare results from across the region and set runoff coefficients for use in the final set of models runs. Though the data was collected during California's most severe drought year, the results were comparable to national averages.

A final set of model runs was made in each county using the latest projection data and runoff quality coefficients based on the local sampling data. This last set of runs was made in a relatively short period of time, attesting to the success of the training program. Some counties performed well beyond ABAG's expectations. One county calibrated its model using runoff data and 25 years of rainfall records. This county felt very confident that its annual average pollutant loads were accurately predicted.

Plan Development

The most difficult part of the planning process was the drafting of the actual plans. Since county staff members were writing their own plans, they wanted to be very careful that the plans were politically and economically acceptable. They wanted to be sure that what they proposed would be acceptable to their respective county boards of supervisors.

ABAG, on the other hand, wanted to be sure that the county plans would meet EPA's requirements. EPA's primary concern was that the plans be implementable. ABAG also wanted to ensure that the plans were regionally consistent. While the counties continually emphasized their individuality and their desire to tailor plan recommendations to the unique qualities of their jurisdictions, ABAG strove to set minimum standards for plan development.

One requirement which ABAG imposed was that all counties had to consider the same list of surface runoff control measures. A comprehensive list of these control measures was included in each county's contract. Throughout the two years of the program, information on the use and cost-effectivenes of these measures was provided. The information was disseminated in the form of handbooks, reports, technical papers and workshops. (13) (There were two workshops on control measures.) The counties were not required to include all these measures in their plans. They were, however, required to provide reasons for not including particular measures.

In addition, a standardized plan format was prepared. This format specified that for each action in the county plan, the following information was to be provided:

o implementing agency

o implementation schedule

o financing mechanism

o legal authority and enforcement. (14)

Implementation Agreements

In September, 1977, more than half way through the two-year program, EPA added the additional requirement that commitments from designated implementing agencies had to be obtained. (15) Thus, all implementing agencies in the county surface runoff plans had to agree to implement their portion of the plan. Counties could therefore not unilaterally assign responsibilities to local agencies without at least discussing it with them first.

Because the requirement to obtain implementation agreements was not in their contracts, the counties were initially reluctant to take on this added burden. ABAG then agreed to take major responsibility but requested county assistance. These terms were acceptable to the counties.

The draft county surface runoff plans were due by September, 1977--barely 15 months into the 24-month program. This early submittal was required in order to accommodate the lengthy review process. Nearly all the counties produced their draft plans on schedule. With one exception, all the counties produced plans in the format requested by ABAG. Of the 40 surface runoff control measures which ABAG required the counties to consider, 28 appeared in the county plans in some form.

All eight county plans contained recommendations to:

- o improve street sweeping
- o control erosion
- o establish a public education program.

Six plans contained recommendations to:

- o establish a water quality monitoring program
- o clean catch basins and storm drains
- o control dumping and littering. (16)

When the draft plans were completed by county staffs, they were "approved for transmittal to ABAG" by each county's board of supervisors. The plans were then subjected to an arduous review and approval process lasting nine months. The reviewing agencies included ABAG (and its EMTF), RWQCB, the State Water Resources Control Board and EPA. In June, 1978, the county surface runoff plans were incorporated by reference into the Bay Area Environmental Management Plan. This plan was then approved by the cities and counties of the Bay Area at ABAG's General Assembly. The Bay Area's "208" plan (the EMP) was certified by the State Water Resources Control Board in September, 1978, and approved by the Environmental Protection Agency in February, 1979.

One of ABAG's first major activities following General Assembly adoption was to seek and secure commitments from management agencies listed in the "208" plan to implement portions which they had been assigned. ABAG drafted a model "Resolution of Intent" which was used by local governments in the Bay Area to express their intent to implement the plan. This procedure was quite successful; the effort generated management agency agreements from eight of the nine counties in the water quality planning boundary and 73 of the 84 cities, including all cities over 50,000 in population.

THE PUBLIC PARTICIPATION PROGRAM

The Environmental Management Plan--which encompassed the surface runoff program--received the most extensive public involvement any Bay region decision had ever achieved, both in numbers of persons and the range of interests represented. Officials of virtually every city and county took part in the decision-making process. In addition to the activities of local governments, about 15,000 citizens had a voice in at least one portion of the public participation program, and hundreds of thousands learned about the plan through the news media.

The ABAG Executive Board and staff made the commitment from the start that citizen participation would be the core of its planning program. There were a number of highly controversial issues to be addressed, and the wisest manner of handling them was to involve all affected parties from the beginning, so that public education would prepare the citizenry for the critical decisions, avoiding disruptive storms of protest over the costs and implications of proposed environmental control measures.

The Environmental Management Task Force was the pivot around which most of the public participation program revolved. This 45-member body met about twice a month, and each meeting attracted an average of 100 visitors. EMTF members had a high degree of commitment to their responsibilities, reflected in an attendance record of about 85-90%. They took considerable personal time to keep their constituencies well informed, through presentations and newsletters. Four policy committees, including a Public Participation Committee, also met regularly to pursue specific areas of concern.

Members of the task force and ABAG staff held special briefing sessions with local officials, labor leaders and conservation groups. Presentations were made to city councils, boards of supervisors, planning commissions, mayors' conferences, city managers' associations, and other key government officials. A special advisory committee of county administrators and city managers worked with the ABAG staff, particularly on the institutional and financial aspects of the plan. Special "EMP Bulletin" reports were prepared for all locally elected officials in the Bay Area.

All nine of the counties and 61 member cities reviewed the plan at regular or special meetings and hearings, and prepared recommended changes. Mayors' conferences and city managers' associations prepared recommendations for plan changes and positions.

The county lead agencies conducted their own review programs for the individual county surface runoff plans. They circulated the plan to organizations and individuals and held numerous meetings and hearings. The boards of supervisors from all eight participating counties met individually to recommend a surface runoff program to ABAG.

Liaison teams composed of EMTF members from each county contacted citizens and officials in their counties and held sets of roundtable discussions in each area. They identified local concerns and reported them back to the full task force. Resulting actions of the task force were then reported back to all participants.

A speakers bureau provided programs for groups such as labor councils, economic development associations, school classes, service clubs, conservationists, homeowners and manufacturers. Several hundred meetings were held by local groups to review the plan and prepare responses. In the end, 116 organizations proposed amendments to the plan. A number of labor, business, and conservation groups assigned members or staff to work full-time on plan review, preparation of responses and lobbying.

Heavy media coverage of the plan review and adoption alerted tens of thousands of citizens who had previously been uninvolved. Many joined the review and approval of the plan through workshops, informal discussions and formal public hearings which the task force held throughout the region during the months before final adoption. During the review process, citizens were urged to talk with or write to their city and county elected officials.

At least 20 of the region's major newspapers, the seven major television stations, and most of the radio stations covered progress of the plan. Over a dozen radio and television stations aired half-hour interview programs; others ran one- to five-minute specials during newscasts.

Key support materials were prepared by the ABAG staff:

- o An extensive mailing list for contacts with groups and individuals in the region was expanded to more than 7,000 names. Most of these contacts received the monthly agency bulletin, Bay View.

- o Popularized summaries of the program included a mail-back opinion and information questionnaire.

- o Progress reports received wide distribution, including reprints by two private industry groups.

- o The full 600-page draft plan, an 80-page summary, a 16-page tabloid summary, and a 110-page listing of all proposed policies, actions, costs and impacts were printed separately for broad dissemination.

- o Copies of a four-page tabloid,"Plan Highlights," were printed in English, Spanish and Chinese. Three revised editions were printed to reflect changes made by the task force and the ABAG Executive Board. (Many county lead agencies prepared summaries of the plan for use by governments and groups in their areas. Special interest groups also prepared and widely distributed their own reports and newsletters analyzing the plan.)

- o A 13-minute slide-tape show describing the EMP was loaned to county lead agencies and citizen groups. Two films were prepared by persons at Stanford University and the University of California at Berkeley, with limited assistance from ABAG. These audio-visual materials were designed for and used on TV as well as with discussion groups.

- o Twelve depository libraries were established--at least one in every county. The libraries continue to carry copies of all technical and popularized materials, which are routinely updated by ABAG staff members.

As a result of this extensive public involvement program, the cities and counties of the San Francisco Bay Area voted overwhelming approval (71-5) of the massive plan. The plan now has strong public support, bolstered by state legislation that prevents state agencies from changing the ABAG plan without local review and approval.

The surface runoff program was a key beneficiary of the public participation program. As a result of ABAG's philosopy that involvement of the public and member governments was essential from the outset, the final plan was one that would satisfy most individual concerns. The response of member cities and counties in signing surface runoff contracts was proof that the ABAG approach was a sound one.

No major challenge was raised at the end of the program to claim that groups or sectors of the public had been neglected or barred from the process. Instead, representatives of most, if not all, public and special interest groups on the EMTF attended a news conference a month before the General Assembly to express their support for the plan and their willingness to continue to participate.

Further confirmation of local support was received when a House of Representatives subcommitee held hearings on the Environmental Management Plan soon after its adoption. The testimony of elected officials and citizen groups alike strongly endorsed the ABAG process and the final approved plan.

CONTINUING LOCAL INVOLVEMENT IN WATER QUALITY PLANNING

Local involvement in the surface runoff program did not end with the completion of the county plans in June, 1978. Throughout the plan development, ABAG staff had encouraged the counties to develop six-year surface runoff plans. As the plans neared completion, ABAG requested the counties to prepare detailed work plans for the first one to two years of plan implementation. A technical memorandum was prepared which outlined a six-year work program and provided detailed examples for the first year tasks. (17)

When EPA announced that funds were appropriated to continue the "208" program into 1979, ABAG asked the counties to submit their proposals. Again, ABAG provided the format and a description of what was needed. Of the eight counties that participated in the initial program, six submitted work plans to continue their work. In addition, a work program was submitted by the Council of Bay Area Resource Conservation Districts. These work plans ranged from a modest $60,000 proposal to an ambitious $200,000 effort. Unlike the initial program, which was 100% federally funded, the current program required a 25% local contribution.

ABAG presented the county workplans, together with its own proposal, to the RWQCB. After a relatively short negotiation process, ABAG and the RWQCB presented a joint workplan for 1979-80 to the State and EPA for approval. The total budget for county planning was about $250,000. In April, 1979, EPA awarded a grant to ABAG which funded all but one task in the joint work plan. (18)

By their participation in the development of the 1979-80 workplan, the counties expressed their commitment to continue the planning process. The six participating counties not only agreed to seek implementation of the 1979-80 plan recommendations, but had committed local funds to the process. One county hired a full-time "208" coordinator to continue the work before anyone knew there would be federal "208" funding for the Bay Area beyond 1978.

The county workplans for 1979-80 focus on the problem of erosion and sedimentation. These workplans include tasks to:

- o evaluate and improve city and county ordinances and project review procedures to more effectively control construction erosion
- o develop and implement best management practices in rural areas
- o review and improve surface runoff control measures, such as street sweeping and catch basin cleaning. (19)

CONCLUSION

The spirit of cooperation shown by the counties over the past three years demonstrates that local support for surface runoff management in the Bay Area has been achieved. Early in the program local governments had expressed considerable concern that higher levels of government would impose their solutions on local governments. This early distrust has gradually given way to a cooperative attitude. Local agencies better understand surface runoff problems now and they are taking more of a leadership role in developing solutions. ABAG is no longer viewed by some as an arm of the State and EPA, but more as a resource and an assistant to local government. The "them vs. us" attitude of the past has all but disappeared.

Surface runoff problems are widespread, highly complex and difficult to control. These problems cannot be controlled without the support of local government. The progress made in the past three years has been great when one considers that surface runoff has been virtually ignored in the 200 years of this nation's history.

While it is no doubt true that a more rigorous technical product could have been produced if highly trained specialists had prepared a surface runoff plan for the Bay Area, the chances for implementing such a plan would have been small. The past history of water quality planning in this area has proven that. The county surface runoff plans have a very good chance to succeed as long as there is continuing support for "208" planning on the national level. It may well require 20-30 years to solve these nonpoint source pollution point problems. However, when one considers that point source problems have taken at least that long to control, the time frame is not so unreasonable.

Local support for surface runoff management in the Bay Area has been achieved by giving local governments the ability to make their own choices. They were given funding and technical assistance to allow them to understand the problems. They were also given the opportunity to find solutions that would be locally acceptable. These solutions cannot be implemented overnight. Congress and EPA must realize this fact and should continue to support the gains made during the last three years.

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IV. INSTITUTIONAL ASPECTS OF IMPLEMENTATION

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ADDRESS BEFORE THE NATIONAL CONFERENCE ON STORMWATER MANAGEMENT ALTERNATIVES

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I hope to give you a little insight into how the EPA views Stormwater Management problems and possible solutions to them.

The Federal Water Pollution Control Act Amendments of 1972 gave our country, for the first time, effective legislation for controlling water pollution. The provisions of the act give a good indication of the viewpoint many held at the time as to the solutions to our water pollution problems. Those provisions are overwhelmingly oriented towards point-source control.

The keystones of the Clean Water Act were, and continue to be, the Grants Program for Construction of Municipal Sewage Treatment Facilities under Section 201, and the National Pollutant Discharge Elimination System Permit Program under Section 402.

Non-point sources were also considered of concern, but certainly not of equal importance. Control of these sources was left to the voluntary use of best management practices to be developed under Section 208 Water Quality Management Plans.

And yet, while the Construction Grants Program and the NPDES Permit Program have gone a long way in controlling wastewater discharges from municipal and industrial sources, it has become quite apparent that without effective non-point source control also, we will not be able to achieve fishable and swimmable waters at any time, let alone the 1983 deadline set by Congress.

Research done in part under Section 208 has shown clearly just how important non-point source pollution control is, and stormwater runoff, particularly in urbanized areas, has been found to be one of the most widespread and difficult of the non-point sources.

Consider the following statistics:

- Fifty-two percent of the nation's 246 river basins are affected by urban runoff. In the Northeast, this figure is 70 percent.

- At least 37 states have reported that they will be unable to meet 1983 goals in at least part of their water because of runoff.

- Although toxic metal loadings are difficult to estimate on a national scale, studies of individual cities have shown concentrations of certain toxic metals in urban stormwater runoff to be many times greater than the concentrations found in municipal sewage.

• By 1981, loadings of biochemical oxygen demand from untreated urban runoff will equal those from treated municipal effluent and combined sewer overflows. In fact, BOD concentrations from some non-point sources are estimated to be as much as five times higher than from treated point sources or natural background.

• Sediment loads from man-made non-point sources are estimated to be 360 times higher than those from point sources, and three times higher than natural background.

• Total nitrogen from non-point sources is estimated to be four times higher than point-sources and three times higher than natural background.

• Total phosphorus from non-point sources is slightly higher than from point sources and twice as high as natural background.

• Loadings of fecal coliform from non-point sources will be at least 50 times higher than from point sources, once secondary treatment with disinfection is achieved for all municipal sources.

But beyond these numbers, there is the actual harm to the quality of life caused by urban runoff. The list of examples is long, but allow me to highlight a few:

In the Baltimore, Maryland area, many streams have been severely degraded as a result of urbanization. These waters are unsuitable for human or animal contact and recreation purposes.

Few streams in the Washington, D.C. area consistently meet bacterial standards due to urban runoff, and most are considered unfit for water contact recreation. Sedimentation from man-made activities is reducing the storage capacity of the Occoquan Reservoir, one of the major water storage facilities for northern Virginia. High levels of suspended solids due to runoff periodically require more costly drinking water treatment to be used.

But, recognizing a problem and dealing with it are two different things. There are still large gaps in our knowledge about some treatment techniques, especially the cost-effectiveness of various alternatives.

The latest "Needs Survey" conducted by EPA and the states indicated that structural solutions to urban runoff would cost almost $62 billion. Frankly, given the needs for other types of water pollution control, it is doubtful that Congress would ever appropriate money for a control program of this size. However, the use of many best management practices is much less costly. For example, we estimate that the expenditure of some $6.6 billion for BMP's could significantly reduce the effects of urban runoff.

But there are still additional questions that need to be answered. We must find better information on how specific sources impact actual stream quality, and we must know more about how well specific control measures work. We must also know if techniques used in one geographic area are transferable to other areas with similar water quality problems.

Until these questions are answered, I believe that Congress is right in being reluctant to provide funding for implementation of most best management practices. But the EPA is doing several things to improve our knowledge. The most important of these is, I believe, the Nationwide Runoff Program, also known by the acronym NURP.

NURP is directed toward a review of what is known about urban runoff, its causes and its controls. The strategy is to test urban best management practices under controlled conditions in prototype projects. Projects have been selected in areas representing a range of climatic, hydrological, and physiographical conditions. In-depth water quality monitoring, both before and after controls, will improve our understanding of the cause and effect relationships between pollution controls and water quality. These projects, I believe, will be developing data that is not available at this time.

Once non-point source control techniques are tested in the field, we will be better able to transfer to similar communities those technologies which proved the most cost-effective and appropriate. This should save a considerable amount of time and expense in testing for solutions. In order to give you a better idea of what a NURP project involves, let me explain two projects going on here in Region III. These projects are located in Baltimore, Maryland and Washington, D.C., and are designed to solve some of the water quality problems of these areas that I outlined earlier. While they are only two out of the 30 projects nationwide, they should prove to be typical of situations found in many large older eastern cities.

In Baltimore, the NURP project is being conducted by the Regional Planning Council, which was responsible for preparing the 208 plan for the area. The project focuses on a portion of the Jones Falls watershed which is located both in the city of Baltimore and some outlying areas of Baltimore County.

The study will emphasize the need for intergovernment cooperation between jurisdictions which share a common body of water. A number of best management practices currently being used in the area will be analyzed to determine their transferability to the nearby Gwynn Falls Basin.

In the District of Columbia, the Washington Metropolitan Council of Governments is responsible for the NURP study. Again, COG was the designated 208 agency for the area.

This study will develop a cost-effectiveness analysis of various best management practices and will calculate actual dollar costs of removing specific amounts of pollution. Such information will allow us to determine with more accuracy the tradeoffs between controlling varying amounts of point and non-point source pollution.

Two watersheds in the area that are critically impacted by runoff will be selected for intensive study.

In addition to NURP, other programs will focus on additional non-point programs that impact our urban areas. Specifically, I would like to outline the Rural Clean Water Act Program, which is often referred to by the letters RCWP.

RCWP concentrates on agricultural non-point sources. It differs from NURP in that it provides funds for actual implementation of best management practices. Individual farms in critical water quality areas in specific basins will be selected for study. If the current funding request of $50 million is appropriated by Congress, some 25 to 35 basins will receive grants.

So far, I have concentrated on the technical problems facing implementation of non-point source pollution controls. However, there are political problems just as perplexing. State and local decision makers find many barriers in their path, including confusing regulatory requirements, lack of priorities, and a shortage of funds.

In these areas, EPA is also doing something to help.

For example, for activities under Sections 208, 303(E) and 106, we have consolidated their requirements into a single water quality management program. In case you are unfamiliar with any of these sections, they all concern water quality management studies, planning and implementation carried out primarily by the states. The regulations implementing this change represent a significant simplification of the process.

Another improvement in management is the state/EPA agreement. This is an annual agreement negotiated directly between each regional administrator and state officials, usually the Governor.

Each agreement identifies problems, sets priorities, and plans activities for water quality, solid waste, drinking water, and other programs which the state and region agree to include. It recognizes that a pollution problem may have many dimensions and focuses the appropriate resources and programs upon those problem dimensions.

While the implementation of non-point controls faces political and technical barriers, one of the largest issues appears to be financing. This is not surprising considering the limited federal funding potentially available, the increasing competition for scarce resources among state and local priorities, and the reduction of state and local funding sources. In this environment, the most practical approach for achieving implementation is to ensure that fiscal impact analyses are part of every non-point control proposal. It is also important that state and local decision-makers be provided all the information necessary to make a sound choice among alternatives.

In order to help in this, the EPA has initiated a financial management training and technical assistance project for state and local water quality managers. This project will help them to utilize sound fiscal policies, financial planning, and management approaches in implementing water pollution control programs.

I hope that this brief review of EPA's non-point source control activities has proven informative and helpful. But underlining these remarks is a point which I think deserves emphasis. The solutions to non-point source pollution are such that voluntary compliance is probably the only way to go given the powers of the respective levels of government. And whenever we must rely on voluntary compliance, we must also rely on public acceptance and support of the proposed solutions.

I know there is a great deal of expertise here in this room, and I don't doubt for a minute that collectively we could propose alternatives that would be best for the vast majority of our country. But we must never forget that the average citizen, more than ever before, has a healthy scepticism of what the "experts" have to say. Therefore, we must always include the public in our deliberations, and get them to understand that we understand their problems.

A good example of this was seen in a southern Congressman who always went by the name of Private John Allen of Tupelo, Mississippi. He always carried the title "Private" because of the way he was first elected in 1884. His principal opponent that year was a General Tucker, late of the Army of the Confederacy, the same army in which Allen had served as a private. In one debate, the General contrasted his high rank with that of Allen's.

"Yes, sir," said Allen, "I admit I was only a private. In fact, I was a sentry who stood guard over the general while he slept. So all you fellows who were generals, and had privates standing guard over you, vote for General Tucker, but all of you boys who were privates, and stood guard over the generals, vote for 'Private' John Allen."

They did, and he served for the next sixteen years.

If we want to see our ideas still around after sixteen years, we must do what Allen did and appeal to the average citizen.

We must educate them about the problems and various solutions. We must make them understand that stormwater can be made into a resource that can actually enhance their health, safety, and recreational activities.

EPA has shown its commitment to this concept by the public participation requirements included in all of our water quality programs, and I hope _you_ can join us in these efforts.

I believe that sessions such as this conference are a major step in this direction, so that regulatory authorities and water quality professionals can develop an even closer cooperation in our nation's campaign for clean water.

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LET'S SETTLE THE STORMWATER MANAGEMENT ISSUE

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Beginning in the mid-1960's, the United States realized that urban runoff, both from separate and combined sewers, constitutes a serious pollution source. Since that time, millions have been spent on research and demonstration projects and a number of installations designed to halt combined sewer overflow (CSO) have been built. Meanwhile, local governments have continued to manage development and billions of dollars of stormwater management facilities in the form of gutters, pipes, ponds, ditches and canals have been built. We see evolving a field called "stormwater management" which is seized upon by many (including the writer) for more research and studies. Congress delays decisions about non-point runoff control because we really do not know how to control the urban sources. It seems that more progress should have been made. One of the problems has been the traditional separation between the "talkers" and the "doers".

This paper will describe who the "talkers and doers" are and show how our national programs could be more effective. It will describe a recent policy-related stormwater conference which compared local, state and federal programs in the southeast. The conclusions of this conference have a lot to say to policy-makers at all three levels of government.

Definition of Stormwater Management

The term "stormwater management" means different things to different people. To the writer, the following definition applies:

> "Stormwater management is the set of actions taken to control water in its hydrological cycle with the objectives of providing: surface drainage, flood control, erosion and sedimentation control and reducing pollutants in runoff."

Note that it includes four separate objectives. It applies to rural and urban areas, but is most relevant in urban situations. It requires the application of planning, engineering analysis and design, and other management techniques. It does <u>not</u> apply solely to urban runoff pollution control nor to drainage. It is a <u>multi-objective activity</u>.

Stormwater management has been applied and practiced for a long time. Of course, in the United States the original sewers were for storm drainage and it was the connecting of house and industrial sewers to them that created the combined sewer problem. Roadbuilding has always required careful attention to drainage and many of the best guides for drainage practice came from the roadbuilding profession. The Soil Conservation Service has been practicing stormwater management in conjunction with their conservation objectives for many years. Every public works director and city engineer practices stormwater management as a matter of necessity. Thus, there are a number of "doers" already in the stormwater management business.

The writer has mostly worked with the "talkers". They are the researchers, the federal and state government personnel and the professors who have pursued research and discussion concerning CSO and runoff problems. There was money available to study the "urban runoff" problem and a great deal of research has been done. Most of this was low-budget research with national totals running less than, say, \$10 million per year since 1970. The writer estimates "stormwater management" to be an economic activity on the order of \$5 to \$10 billion annually, including capital and maintenance expenditures. The \$10 million research figure thus represents about 0.1 percent of total stormwater management expenditures. These figures are very approximate, but the result should be basically correct.

Much of the research has been published in the journals and reported at conferences, but little diffusion into practice has occurred, except for the practice of detention storage, which has mostly been used to reduce quantities of runoff and not for pollution control. In spite of this lack of diffusion of research results, management is probably very high, mostly due to the low cost. The "talkers" have contributed a great deal -- but they have not solved the stormwater management question.

The Problem

In addition to the low total research expenditures, the writer believes that too much of the work addressed to solving the stormwater management problem has gone into the development of advanced tools and techniques with long-term possibilities for developing pollution control programs, but which are a long way from the practical arena of the city engineer. Some of these which I have personally worked on are models, automatic control techniques, and structural stormwater treatment facilities. Most of these will probably not be in daily use in small-to-medium sized US cities until into the 21st Century. Some are, of course, useful now. They still do not, however, solve the stormwater management question.

Thus, we have a great gap facing us. On the one hand, to clean up all urban non-point runoff pollution with structural measures could cost tens of billions of dollars, and on the other hand, the tools and techniques we have developed so far have not led to cost-effective and practical solutions.

I believe that, when it is all said and done on urban runoff quality, that we will implement programs aimed at integrating better housekeeping into normal municipal practice. There will be changes anyway in the form and style of American living, some brought on by the energy shortage, others brought by the communications revolution. Automobiles will be with us for a long time, however, and the existing stock of US housing will have to last well into the next century. Stormwater management programs will be shaped by the old and the new. There will be few dramatic surprises. However, we already know much of what we will ever know about the extent of this problem. We ought to be working more deliberately on solutions that can be implemented and that will be accepted.

Some of the better "on-the-shelf" measures we already have are street sweeping, control of litter and dump sites, control over air pollutants, deliberate and wise use of detention storage and, in general, more attention to stormwater management programs at the local level.

In developing countries where there is rapid urbanization, stormwater management and the cleansing of urban and other receiving waters will be a much greater problem. Bad sanitation, lack of housekeeping and overpopulation, all of which affect urban stormwater management, are all problems endemic to these countries. In the US and Europe, the present and future form of our cities is pretty well known, however, and we can afford to begin solutions much more optimistically.

The Southeast Conference on Urban Stormwater Management

In April 1979, the Conference on Stormwater Management was held as one of several sponsored by the state water resources research institutes on water problems of special concern to the southeastern states. Almost all of the participants were "doers", although a few researchers and professors slipped in. The results were very interesting and not at all surprising.

The eight states represented had a great deal in common. As usual, most state government programs were in response to Federal programs. That meant that most of the states were working on urban runoff quality as part of the "208" process, but had few, if any, programs in urban drainage or flood control. Most of the states have some programs in flood insurance started in response to the initiatives of the HUD regional efforts (the Flood Insurance Program has now moved from HUD to FEMA). Again, the Federal Government has little in the way of erosion and sedimentation programs for urban areas and this is reflected by the states, although several states have begun some regulatory efforts to control erosion from land-disturbing activities.

Local governments, being very close to the people, have many day-to-day pressures related to stormwater management. These include drainage and flood control, some erosion problems, and some pressure for cleaner urban streams. With some exceptions, the local governments do not feel much in touch with the efforts of the state and federal governments to clean up urban runoff pollution through the "208" programs. This is because they are busy putting out other fires at home. Yet it is the local governments that will eventually have to solve the stormwater management question.

Both EPA and the USGS are busy trying to develop programs of study and data collection that will help to pinpoint the sources of urban runoff pollution. The writer believes, however, that through common sense and plain eyesight we know where most of the problems are already. The literature reflects this and it is not too difficult to find descriptions of non-point pollution sources in urban areas. Thus, remedial action need not wait for the results of the EPA and USGS efforts.

The impressions that the writer received from the Conference were as given below. These are subject to change as the conference proceedings are still under preparation.

1. Most of the attention on how to solve the urban non-point pollution problem is at the Federal level. This attention has been since the middle 1960's and we do not seem to be any closer now to an overall solution then we were then, although we do have a formidable arsenal of tools and techniques produced from research projects.

2. With some exceptions, local government has not participated much in the debate about urban non-point pollution. There is however a great interest in general stormwater management.

3. No one seems to think that any magic solution to the urban non-point pollution problem is at hand and the country cannot afford the tens of billions of dollars that would be necessary for structural solutions. We must begin to implement responsibly the cost-effective tools we already have.

4. There is a great deal of expertise available at the local level to respond to common sense solutions, especially those with demonstrable benefits for local areas. This expertise is not now being called on by the federal or state governments to work on stormwater management. Most of the innovations taking place are by "doers" at the local levels.

5. There is a natural hierarchy of activities for the three levels of government in stormwater management: a) Federal Government issues legislation, makes grants and does research; b) state government transfers technology and works with Federal Government to develop regulations and programs of assistance to local government; c) local government implements programs.

Some Elements of the Solution

The writer does not have the ultimate solutions. The following are some ideas, however, which might be considered by Federal action agencies and by the local governments.

1. Stormwater management must be viewed as a multi-objective activity with four objectives.

2. We already know most of what we can ever expect to know about the problem. The Federal Government should decide to mount an attack using incentives and other means and begin to shape attitudes and practices that are responsible, helpful and which will be accepted at the local level. We still need further research, but we cannot afford to wait for it.

3. The Federal Government needs to make a commitment to work in all four areas of stormwater management over a long period of time and to mount a program of financial incentives and leadership that will motivate the private sector, local government, state government, the professional associations and universities in a coordinated attack on this problem.

4. The professional associations need to be more widely recognized as leadership organizations for stormwater management and to mount programs in cooperation with the Federal Government that will raise the professionalism of their membership and help to improve stormwater management. The lead organization, in the opinion of the writer, should be the American Public Works Association. This is because of the grass roots public works nature of its membership and the practical level on which they work. There are roles for the other associations as well. Noteworthy is the Urban Water Resources Research Program of the American Society of Civil Engineers which has been a leader in advanced research.

Some of the shorter term goals that should be encouraged are as follows:

1. Every municipality should have a comprehensive stormwater management plan that recognizes drainage, flood control, erosion and runoff quality.

2. City engineers and planners should be much better trained in the tools and techniques of stormwater management.

3. The professional associations and the water research institutes should get together and sponsor some practical conferences on real solutions to stormwater management that can be implemented.

4. A Federal agency, the professional societies or associations of state or local governments should develop better model legislation for state and local government for total stormwater management. Single purpose legislation, such as for flood plain management, should be used with extreme caution.

5. Cities should be encouraged to follow-up their planning process with data collection and monitoring. They should find out where their runoff quality problems are and how bad they are.

6. New technology should be diffused throughout the professions that are concerned with stormwater. The technology should be effective and make sense economically so that it will, in fact, be adopted.

Thus, there are roles for both the "talkers" and the "doers" in stormwater management. The time to begin is now and the way to proceed is in partnership. The Federal Government should lead the way. Effective leadership will find solutions without the expenditure of tens of billions of dollars on pollution control alone.

In closing, I would like to state that the role of the "talkers" is absolutely crucial in stormwater management. Although I conclude that all our research has not solved the problem, the nation can be proud of the results of its investments in research and demonstration. Some very excellent programs have been mounted through the EPA, USGS, the Corps, DOT and OWRT. Without this research we would not even know what the problem was. Although we should not wait for the results of research to begin implementing solutions, continued research is likely to save billions of dollars and lead to much cleaner water at a reasonable cost.

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THE GREENWAY CONCEPT WITHIN THE HERITAGE CONSERVATION AND RECREATION SERVICE

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I. Introduction

The U.S. Department of the Interior's Heritage Conservation and Recreation Service, often referred to as HCRS, through the Nationwide Rivers Inventory, has established a comprehensive river information system which can serve as a framework and a focal point for greenway conservation activities. The Inventory, being conducted under the National Wild and Scenic Rivers Act (P.L. 90-542), does several things:

- It provides recognition and the option for varying degrees of protection to significant river resource areas to avoid adverse environmental impacts and to upgrade the public's awareness of these valuable resources.

- It serves as a focal point for the more effective coordination and use of existing Federal activities and programs related to greenway conservation.

- It establishes a data base of objective and descriptive river resource information for planning and decision making.

- It identifies through the use of a "grass-roots" communication network, opportunities for greenway conservation implementation including information about local and State issues and conservation supporters.

- It identifies and emphasizes greenway conservation implementation options at all levels of the government and the private sector including funding programs, legislative tools and techniques, and less-than-fee-acquisition strategies.

HCRS's national greenway conservation effort is based on the philosophy that river conservation is a shared responsibility between all levels of the government and the private sector.

The basis for the Federal government's involvement in greenway conservation is mandated by a variety of laws and policies. However, to understand the activities of HCRS and the Nationwide Rivers Inventory, it is essential to understand the policies in the Wild and Scenic Rivers Act.

II. National Wild and Scenic Rivers Act

In 1968, after 6 years of discussion and debate, Congress enacted P.L. 90-542. The "Act" established a policy that certain selected rivers of the nation with outstanding values:

First - Shall be preserved in a free-flowing condition.

Second - Shall be protected for the benefit and enjoyment of present and future generations.

The purpose of the "Act" is to institute a national system of rivers. The intent of P.L. 90-542 was to establish a river conservation policy complementary to the existing national policy of dam building. P.L. 90-542 is fairly specific regarding the characteristics that a river must possess to be eligible for the National Rivers System. The law states that a river must:

- Be free-flowing.

- Be free of significant water-related types of development (i.e., channelization, dikes, levees, etc.)

- Have watersheds or shorelines which are relatively undeveloped.

- Have an outstandingly remarkable value (i.e., scenic, recreational, geologic, fish and wildlife, historic, cultural or other).

A variety of agencies, at all levels of the government, are involved in the planning and implementation of National Wild and Scenic Rivers Act.

- The National Park Service conducts Congressionally mandated Wild and Scenic River Studies.

- The National Forest Service studies potential National rivers which flow through U.S. Department of Agriculture lands.

- State, local and regional government agencies may also have a direct responsibility in planning and implementing Wild and Scenic Rivers.

The Act recognizes that different options for conserving "greenways" are appropriate for different types of rivers and communities. No one approach to conservation is suitable for all areas. Specifically the "Act" provides for:

- National designation of selected rivers. This may occur as the result of a State initiated action Sec. 2(a)(ii) or at the direction of Congress Sec. 2(a)(i).

- Designation for potential addition to the national wild and scenic rivers system Sec. 5(a).

- Identification of additional wild, scenic and recreational river areas to be evaluated in planning reports by all Federal agencies as potential alternative uses of land and water areas. Sec. 5(d).

- Assistance to States for establishing State and local wild, scenic and recreational river areas.

- Provision of technical assistance to States, political subdivisions, and private organizations to establish wild, scenic and recreational river areas.

Although the "Act" was established primarily to set a policy for "certain selected" nationally significant rivers the Inventory, mandated by this legislation establishes a means to conserve additional greenway areas of State and local importance.

The major purposes of the Nationwide Rivers Inventory are:

- To identify and evaluate all of the significant rivers of the nation.

- To determine the suitability of rivers for further study and/or potential inclusion in the National Rivers System.

- To identify for the President and Congress the parameters of a basic National Rivers System.

- To stimulate actions, at all levels of government and within the private sector, which will assure the conservation of and public access to these rivers.

The potential scope of the National Rivers System could include river corridors both publicly and privately owned and of national, State and local significance. These corridors should be representative of the full range of different rivers and landscape types. Such a river system could include wild and natural rivers; rivers of historic and cultural significance; rivers suitable for specific types of recreational use; and urban rivers.

Obviously such diverse river areas require different approaches to achieve greenway conservation goals.

In addition, the people who own and use these rivers have varying ideas of how they are to be used. Specific issues often arise in the competition for these resources dividing persons into conservation proponents and opponents. Implementation strategies, for these various situations, must be both comprehensive and flexible.

In response to these key concerns, HCRS has developed a comprehensive river information system to identify and evaluate:

- Water and land resources

- Social resources

- Local support and issues

- Implementation techniques

This information system, which relies on multi-government level coordination, and "grass roots" creates a framework for decision making information which can be expanded, improved and used for a variety of purposes.

III. River Information System

The "Act" is specific about the qualities which must be present in order for a river to be considered for the National System. Section 1(b) of the "Act" states that these certain selected rivers of the nation - with their immediate environments possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values, shall be preserved...

To fully recognize these "immediate environments" of the river and river corridor,it was determined that a system be developed to record and evaluate the "outstanding" features or characteristics of a river. This system identifies the significant features of a river.

The purpose of this portion of the Nationwide Rivers Inventory is to identify, describe and evaluate those significant physical, natural nd social characteristics of a river or river segment and its corridor, and to give an indication of the types and amounts of features that may be found within a particular river area.

Two issues are extremely important to note concerning this process. First of all, this study is a broad thirteen state survey and should not be confused with a site specific river study. Secondly, with limited resources to perform this evaluation, it has been essential to develop a process that identifies rivers (and their immediate environments) of high quality quickly so that more time could be spent evaluating river areas of greater significance.

This attempt to assess as many rivers as possible, in such a brief period of time, has required the effective use of vast amounts of information about rivers and the landscape that exists within the northeast region and to rely heavily on those persons who are most familiar with these resources.

The study used five major techniques to gather information about rivers and river areas:

Existing research - an exhaustive literature search and review was conducted to identify and use all of the existing sources of information about rivers and river areas. This information ranged in form and in detail, including natural areas studies, river studies, resource inventories, the National Historic Register, the Endangered Species List, canoe guides, and coastal zone management reports.

Expert testimony - river experts were identified within the public and private sector, sought out and asked for comments and information about specific study rivers. These experts were also urged to check the rivers under evaluation to insure that no significant segments had failed to be identified.

Nominations - persons, regardless of affiliation or expertise were encouraged and requested to submit nominations for rivers to be considered for evaluation. Numerous suggestions, with a variety of accompanying materials, were sent to the study team for consideration and analysis.

Workshops - a series of information gathering "work sessions" were conducted to solicit additional site specific data about river areas. Sessions were conducted for both the private and public sectors and were officially scheduled and also held at request.

New research - through a variety of resource evaluation techniques, including aerial reconnaissance, geologic interpretations, statistical analysis and a literature search, new research information about rivers was developed and used in these evaluations. These techniques, although used throughout the study, were initially used in a broad generalized fashion. Rivers and adjacent land areas were "highlighted" if there was evidence of state, multi-state or national significance and further examined in detail.

IV. River Evaluation

The guidelines for assessing natural, physical and social river resources in the Northeast Regional Office were developed with a sensitivity toward data base variances and the need for objectivity in resource evaluations. Variations in information required that the evaluations be flexible enough to accommodate a high level of information where it is available, but also be applicable enough to perform a very basic inventory and analysis where the minimum amount of data exists. In order to make the evaluation meaningful, a minimum "bottom line" analysis was performed on all the rivers.

Because data appears in all shapes, forms and sizes, the guidelines had to be explicit enough for a number of different team members with varying expertise to be able to uniformly and objectively record and evaluate information in a consistent manner to insure comparability. The amount and types of information obtained from each of these techniques obviously varies. Information available for one locality may not be available throughout the entire study region. Certain data about a river was site specific in detail while other information, although broad in a sense, gave a general indication about the character of a particular river or the landscape through which the river flows.

Information for the inventory and evaluation was gathered at a variety of geographical scales in order to ascertain the relationship of a river to the landscape, a state, the region and to the nation. The various levels at which information was gathered at are as follows:

National
HCRS planning region
Physiographic province
Physiographic section
State
River segment watershed and viewshed
River corridor
River mile

For the more detailed information about the river corridor - which for the purposes of this study is defined as an area one-quarter mile from the edge of each river bank - information has been gathered, recorded and subsequently evaluated on a mile-by-mile basis. Although an unnatural delineation of the river, this division of the corridor allows for a fairly specific location of information and for quantification and comparability.

A. River Characteristics

The river and adjacent land related characteristics which were inventoried and evaluated in the River Evaluation are as follows:

Physical Characteristics

- Uninterrupted segment length

Hydrologic Characteristics

- Precipitation and snowmelt
- Watershed area
- River gradient
- Water flow
- Water quality

Geological - Ecological Characteristics

- Area land surface form
- Watershed landform - landscape series
- Prominent natural features (characteristic)
- Biotic and abiotic corridor features
  - Wetlands and surface water
  - Channel shape
  - Topographic diversity
  - Vegetative cover
  - Islands
  - Diversity of plant communities
  - Potential for significant plant and animal habitats
  - Rare and endangered species

Wildlands Characteristics

- Watershed land use character
- Degree of land use development in corridor

Scenic Characteristics

- Views
- Types of visual-spatial enclosure
- Landscape quality-character of corridor
- Types of landscape series

Cultural Characteristics

- Unique cultural settlements
- Historical values

National Register sites
State Register sites
Significant period structures-areas
Types of cultural development-landscapes

Recreational Characteristics

Proximity to population centers
Kinds of access
Existing recreational use
Opportunities for fishing
Opportunities for floating
Opportunities for water contact sports
Opportunities for hunting
Pattern of flow from impoundments
Availability of public transportation
Percent of river frontage publicly owned
Number of river crossings
State scenic river designation

Socio-economic Characteristics

Threat of development
Educational opportunity
Degree of citizen support
Degree of political support

A detailed description of the river evaluation methodology in its entirety, including the criteria used, the data sources and the means of application is being prepared.

B. Field Reconnaissance

Helicopter flights were used to examine river corridors once all of the in-house resource evaluation work was completed. The purpose of these low altitude reconnaissance flights was to:

1. Document the conditions of the river and its adjacent land areas including any outstandingly remarkable feature.

2. Insure and update the accuracy and quality of research information used by the study team.

3. Conduct new research in those sections of the region where little previous work has been done.

4. Assist state wild and scenic river programs whenever practical.

Different types of helicopters were used to fly each of the more than 200 river segments that were examined in detail. Color videotape equipment, consisting of a portable hand-held color television camera and a portable video-cassette recorder, was used to record 75% of the rivers examined.

A 35mm camera, used for the remaining 25% of the rivers examined was also used to supplement the video-tapes. To insure continuity and comparability throughout the helicopter flights, team members participated in every river examination within specific sections. State wild and scenic river program staff were invited to participate in the aerial reconnaissance whenever possible since they have an excellent knowledge of the rivers within their states.

The potential uses of the video-tapes and photographs of the rivers examined are numerous. Aside from the obvious use of these photographic records for the purposes of the study, opportunities exist to use these materials in the following ways:

- Tapes and slides can be made available, at cost, to each State's river program, to conservation groups, to private companies and individuals.

- Tapes and slides can be used by the National Park Service, which is now responsible for all Congressionally mandated river studies, to evaluate proposed legislative actions.

- Congressional subcommittees and staffs could examine tapes and slides of rivers for proposed legislative actions.

- Academic institutions could use these materials to conduct certain types of research.

- Other federal and state agencies, such as the EPA, COE, etc., could use those materials in their program activities.

V. Types of Information

A. River Resource Characteristics

The amount, comprehensiveness and flexibility of the information about river areas in the northeast region provides numerous opportunities for analysis. For each river evaluated in the final phase of the inventory, there were between 35 to 50 characteristics examined. These categories represent between 175 to 260 different items of information. Information exists on a mile-by-mile basis and is also in summary form for every river segment studied. Information about a river is, in some instances, displayed as a value assessment about a particular characteristic, for example:

Diversity of Abiotic Corridor Features

High diversity
Moderate diversity
Low diversity

Other information is, in some instances, displayed as descriptive quantitative data about a particular characteristic, for example:

Types of Natural Features (Number of Miles)

Miles with significant wetlands, ponds, or other water features

Miles with diversity of channel shape

Miles with a variety of vegetative cover

Miles with a significant island

All of the evaluations were uniformly applied following definitive procedures in the guidelines. This uniformity and the quantitative and qualitative nature of the resource information allows for any river or rivers to be described individually or compared to each other.

The study has assigned one value system to the descriptive information for the goals of this effort. However, because all of the inventory information has been recorded in a descriptive form, any value system - can be assigned to the data and rivers can be ranked, compared or contrasted.

a. Unique River Features

Because most of the information is in quantitative form, this method can be used to assess the uniqueness of rivers, river areas or specific river features. This concept, although not unique to the person, is based upon a report done by Luna B. Leopold entitled, "Quantitative Comparison of Some Aesthetic Factors Among Rivers." Adapted from that work, an assumption has been made that the riverscape which is unique - that is different from others or uncommon - has a higher level of significance to society than that which is common. The unique values which have been identified can range from the outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values that the "Act" identifies, to other more subtle values such as the number of remaining undeveloped river miles in the agriculturally predominant Piedmont section of the region.

b. Representative River Features

Research was conducted within each physiographic section, to develop criteria to assist in the determination of the "representativeness" of the landscape that the river being studied passes through. These criteria permitted the study team to understand what the representative characteristics of a particular place were so that objective assessments could be made.

The information gathered as a result of this evaluation offers the opportunity to identify those rivers which better exemplify this "representativeness" than others. The physiographic section criteria focused on a representative drainage, landform and topographic features as well as unique features.

B. River Organizations and Interests

In the process of collecting research information about rivers, circulating lists of rivers for review and coordinating with state river programs, a multitude of river related organizations and individuals were identified. A "Directory" of these interests, which range from canoe clubs, conservation groups, city managers, university professors, private citizens and power companies, is being developed to improve communications between HCRS and other organizations and individuals. This type of information is also valuable to conduct more detailed research on a river or a particular issue in an area.

C. Viewpoints on the Impacts of National River Designation

During the course of the Inventory, numerous meetings, workshops and telephone conversations were conducted. Each of these communications were important to the study for two reasons. First of all, various agencies, organizations and individuals provided us with information about rivers in the region which improved our final work product. Secondly, these formal and informal conversations made us aware of a number of outstanding information deficiencies. The most frequently asked question which we were unable to answer - and probably one of the most important issues related to river conservation - was, "What is the impact of National Wild and Scenic River Designation?" To address this question, which has not been systematically researched, the study team prepared a staff working paper. Based on interviews and surveys of knowledgeable individuals living and working in or near one of three existing national wild and scenic rivers, the Allagash River, the Lower St. Croix River, and the Chattoga River, the study examined the perspectives of those who are familiar with rivers already in the National Wild and Scenic River System.

D. Visual River Survey Information

Color video-tapes and 35mm slides were taken of each of the approximately 200 river segments which were examined in detail. These materials, easily and relatively inexpensively reproduced, provide a detailed visual record of each river corridor. These photographic records can be used to conduct detailed evaluation of each river corridor, to "market" the conservation merits of a particular area and to document research findings.

VI. Uses of the Information

A. Information for Decisions

A great deal of emphasis was placed upon the river evaluation portion of this study because it identifies characteristics which are significant, and it provides information which is appropriate to make decisions about river resources.

Descriptions of river corridors were separated from evaluations of river corridor to provide decision-makers with a greater flexibility in the use of this information. Wild and Scenic Rivers Act values have been imposed upon the river information for the specific purposes of this particular study. However, recognizing that values rapidly change, both in planning and in government, the study team felt that this effort would be far more useful if the data was not completely locked into any one set of values.

Statistical descriptions of river resources provide for increased objectivity in comparative evaluations. Descriptive information also allows a decision-maker to determine their own values rather than have someone else's superimposed upon them.

Further flexibility and usefulness is built into this information system through the use of the mile-by-mile recording format and storage of the information on a computer system. Since all of the data has been gathered on a mile-by-mile basis, specific resource information can be easily located, quantified, summarized and compared. River information about a specific, smaller segment can be "broken out" from a larger segment. New information, either site specific or broad in scale, can easily be added to the inventory at any time. Consequently, new categories of information, perhaps related to a new program emphasis, can be added to build upon the inventory.

B. Future Uses

The large amount of data gathered during the study made computerization necessary and economical.

Developed by the Service's Office of Systems Management, the computer system gives HCRS and other users the ability to summarize, compare and correlate river data and to use this data for other purposes and related programs.

C. Resources for Implementation Strategies

Descriptive mile-by-mile resource information also provides data which is useful for developing conservation implementation strategies. Information about the amount of wetland areas, historic sites, endangered species, etc., can provide a planner with a quick indication of the types of legislative and regulatory techniques which can or cannot be used to conserve an area.

D. Examples of the Usefulness of the Information

The information which has been gathered and the methodology for evaluating rivers has proved useful in numerous instances. The following requests were responded to using the Nationwide Inventory:

- March 1978 - House Subcommittee staff request for a list of top quality rivers in the northeast.

- May 1978 - Senator Biden's request for guidance on the potential of the White Clay Creek in Delaware for national designation.

- July 1978 - Representative Harrington's request for an assessment of the Merrimack River in Massachusetts and New Hampshire.

- August 1978 - Secretary Andrus' request that we work with the American Power Company to develop a mitigation package for a nuclear power plant proposal on the James River.

- August 1978 - Virginia Electric Power Company's request to work with VEPCO to avoid possible confrontations on potential power sites.

- September 1978 - French and Pickering Creek Watershed Association's request for an assessment of the potential of the creek for national designation.

- September 1978 - Governor DuPont of Delaware's request for an assessment of the potential of the Choptank and Leipsic Rivers.

- October 1978 - Senator Muskie's request for guidance in working with the Sheepscot River Watershed Association in assessing the potential for national designation.

- October 1978 - State of Maine - three requests came in to help the state evaluate scenic rivers (one from the Land Use Commission another as part of the State's Critical Areas Program, and a third from the Bureau of Parks and Recreation).

- October 1978 - State of Maryland's request for evaluation and tapes of the Monacacy River and Pocomoke Rivers.

- December 1978 - State of New Hampshire - request for tapes of rivers to assist in the development of a rivers program.

- January 1979 - State of Delaware's request for an assessment of the potential of the Nanticoke, Delaware, White Clay and Brandywine Rivers.

- February 1979 - State of New Jersey's request for video tapes of Cedar Creek, the Mullica River "system", Delaware and Great Egg Harbor Rivers.

- March 1979 - Tug Hill Commission's request for video tapes and information on Fish Creek in New York.

- March 1979 - State of Virginia's request for video tapes on selected rivers.

VII. Major Findings

Recently the initial phase of the Inventory in the northeast United States was completed. One hundred and seventy-one rivers and river segments, totaling over 5,300 miles, within 23 different physiographic sections, and 13 States in the northeast United States were identified, as potential National Wild and Scenic Rivers. Over 40% of the rivers identified are located in three physiographic sections. The majority of undeveloped, free-flowing rivers are located at the northern and southern extremities of the northeast planning region away from the major urban areas.

Representative samples of undeveloped, free-flowing rivers in certain physiographic sections such as the Northern section of the Blue Ridge Province and the Northern section of the St. Lawrence Valley Province have virtually been eliminated. Opportunities for natural river conservation in a number of other sections such as the Mohawk Section of the Appalachian Plateau Province and the Southern Section of the Blue Ridge Province have nearly been foreclosed.

Politically, as the data in Figure 1 indicates, the majority of remaining free-flowing, undeveloped rivers are located within 3 States. Over 57% of all rivers identified are located in Virginia, West Virginia, and Maine.

Figure 1

Rivers Identified by States and Physiographic Sections

*Mileage totals do not reflect interstate or international boundary rivers.

STATE / PHYSIOGRAPHIC SECTION	Embayed Coastal Plain	Piedmont Upland	Piedmont Lowland	Blue Ridge - Northern	Blue Ridge - Southern	Ridge & Valley - Tennessee	Ridge & Valley - Middle	Ridge & Valley - Hudson Valley	St. Lawrence Valley - Champlain	St. Lawrence Valley - Northern	Appalachian Plateau - Mohawk	Appalachian Plateau - Catskill	Appalachian Plateau - S. New York	Appalachian Plateau - Allegheny Mtns.	Appalachian Plateau - Kanawha	Cumberland Mtns.	Seaboard Lowland	New England Upland	White Mtns.	Green Mtns.	Taconic	Adirondack	Eastern Lake	5,374 total miles identified
Maine																	173	662	214					1049*
New Hampshire																			160					160*
Vermont									25									37	32	113	8			215
Massachusetts																		11		33	4			48
Rhode Island																								0
Connecticut																		21			32			53
New York	11										18	60	149								10	181	79	508*
New Jersey	169		25					28																222*
Pennsylvania			4				23						40	250										317*
Delaware	58																							58*
Maryland	257	43	82												5									387*
Virginia	420	534	31	31	65	77	105									31								1263*
West Virginia							220							135	432									787
*	915	577	111	31	65	77	348	28	25	0	18	60	189	385	437	31	173	731	406	146	54	181	79	

* 195 miles of rivers form state boundaries.
**112 miles of rivers form international boundaries.

The figures within each of these areas represent some of the last opportunities for the conservation of natural rivers in the northeast. The disproportionate geographic distribution of rivers which were identified can be directly attributed to the physical characteristics of each section and the resultant pattern of land development that has taken place.

Generally, in the more rugged, steep and mountainous areas such as Blue Ridge, Allegheny Mountain and Green Mountain sections, development due to the topography has been forced to locate within the flat and often narrow river corridors. Consequently, few natural or undeveloped rivers remain in these sections. Rivers which have been identified in these areas, such as the West River in Vermont, the Batten Kill in New York, or the West Branch of the Susquehanna River in Pennsylvania usually are recognized for their physical characteristics -- such as historic, scenic, geologic or recreation values.

In contrast, in those physiographic sections such as the Embayed Coastal Plain, the Piedmont Upland and the New England Upland development has generally located away from river corridors due to wetland characteristics and because of the abundance of dry, flat, upland areas which are more suitable for construction. Consequently, numerous natural and undeveloped rivers remain in these sections. Rivers identified within these areas, such as the St. John and the Moose Rivers in Maine, the Mullica River "system" in New Jersey, the Leipsic River in Delaware and the Dragon Swamp in Virginia usually are recognized for their natural characteristics -- such as wilderness, botanic or wildlife values.

Despite the disproportionate geographic distribution of undeveloped, free-flowing rivers in the northeast, over 9% of the river miles identified are located in a relatively close proximity -- within 50 miles -- to high concentrations of urban populations -- cities over 50,000 or more. These rivers such as the Potomac, Lamington-Black, Delaware and Chickahominy, because of their geographic location are a unique opportunity for "close to home" river conservation and recreation.

The diversity of characteristics of the rivers identified vary tremendously. Segments such as the St. John River in Maine are virtually wild and extremely remote rivers while others such as the Housatonic River in Connecticut possess a large amount of culturally significant development and are more accessible. Certain river segments such as the 125 miles of Virginia's Nottoway River are extremely long sections while others, such as New York's 6-mile segment of the Peconic River, are extremely short.

Some rivers, such as the 4-mile segment of the Delaware River, which forms the State boundary between Delaware and New Jersey, are huge, wide, relatively slow moving, tidal rivers, while others such as the 8-mile segment of Virginia's St. Mary's River are small, narrow, seasonally fast moving headwater rivers.

Rivers within certain physiographic areas, such as the Sheepscot River in Maine's Seaboard Lowland section, possess a unique diversity of significant characteristics such as those of historic, hydrologic, fish, scenic and recreation value. One of the most diverse rivers, identified within the entire region, is the 24-mile segment of the Potomac River whose banks lie within the States of Maryland and Virginia. The largest river within the northeast, the Potomac is noted for its hydrologic, geologic, wildlife, botanic, historic and recreational significance.

Certain other river segments, such as 41-mile segment of the Passadumkeag River in Maine have been noted for a singly predominant outstanding feature -- such as significant amounts of wetlands and water features.

Several river "systems" -- a group of small or medium sized rivers hydrologically connected -- were also recognized. The most noteworthy of these rivers is the unique Mullica River "system" in New Jersey. This system, which contains over 104 miles within its 5 river segments, flows within the nationally significant Pine Barrens area.

In a number of instances, due to rugged and mountainous physiographic characteristics, certain river segments, such as the Connecticut River in Vermont and New Hampshire and the Androscoggin River in New Hampshire, possess parallel roads adjacent to or within the river corridor. Although these roads detract from the wild or natural character of the segment, they often offer easy access -- both physical and visual -- to the river.

Certain States such as New York, Pennsylvania and Virginia, due to the variety of physiographic sections within their political boundaries, possess a unique diversity of different types of rivers. Over 70% of all river "types" necessary for a balanced and representative system in the northeast region are present within these 3 States.

Over 85% of all the rivers identified are medium to small size rivers. Undeveloped, free-flowing, large or high order rivers -- those rivers with the greatest size and most constant flow characteristics -- are extremely rare. In fact, approximately 825 miles of large rivers such as the Potomac, the Penobscot, the Delaware and the St. Croix remain in an undeveloped and free-flowing condition. More specifically, this study indicates that, as a river increases in size,the number and diversity of competing interests for its use increases. Not surprisingly, all of the large, high order rivers identified by this study are presently also being examined by a variety of public and private interests for non-conservation uses.

Certain rivers identified flow through a number of different physiographic sections and thus offer a unique opportunity to recognize and conserve several representative river "types" along the same waterway. Although rivers such as the James and Nottoway in Virginia; the Sheepscot and Machias in Maine, and the Westfield in Massachusetts illustrate the physical characteristics of 2 physiographic sections, none can compare with the inherent diversity of the Potomac River. Comprising over 180 miles, within 8 segments, the Potomac River, the largest free-flowing, undeveloped river in the northeast, flows within 5 physiographic sections and the States of Maryland, Virginia and West Virginia.

Three rivers in the State of Maine, within the Seaboard Lowland and the New England Upland sections, totaling close to 120 miles form a portion of the international boundary between the U.S. and Canada. The Missisquoi River, within the State of Vermont and the Green Mountain Section, is a 25-mile segment which begins in the U.S. and flows into Canada. Neither Maine nor Vermont have a rivers program to recognize or protect these rivers.

Approximately 366 miles of rivers, representing 8 physiographic sections in the northeast region, are interstate. An additional 195 miles form state boundaries. The majority of these rivers, which include the Potomac River in Maryland and Virginia, the Delaware River in Pennsylvania and New Jersey and Conneaut Creek in Ohio and Pennsylvania are within States with wild and scenic river programs although, with one exception, none of these rivers are recognized or protected at the present.

Nationally the northeast has fewer rivers in the National Wild and Scenic Rivers System than any other area in the continental United States. Three river segments,representative of 4 physiographic sections within the northeast region, are in the National Wild and Scenic Rivers System. The Delaware River, 64 miles in length from Hancock, New York to below Cherry Island, New York, flows within the Catskill and Southern New York Sections of the Appalachian Plateau Province and the States of New York and Pennsylvania.

The Delaware River, 37 miles in length -- from the southern boundary of the Delaware Water Gap National Recreation Area to Port Jervis, New York -- flows within the Hudson Valley Section of the Ridge and Valley Province and the State of Pennsylvania and New Jersey.

The Allagash River, 92 miles in length from Twin Brook Rapids to the Telos Dam, flows within the New England Upland Section of the New England Province. The Allagash, managed by the State of Maine, was the first northeast river to be placed in the National System.

The Delaware River segments are both unique high order or large rivers while the Allagash, a tributary of the St. John River, is a medium size or middle order river.

As a result of the National Wild and Scenic Rivers Act, a number of States in the northeast established their own river programs. Existing State river systems have had varying amounts of success designating rivers.

Approximately 1,840 miles of rivers have been designated by the State river programs of Maryland, New York, Virginia, Pennsylvania and West Virginia in the northeast region.

Of the rivers identified in the System Study, approximately 5% or 300 miles are designated components of State river systems.

With the exception of Maryland's program, the variety of State rivers designated, within the 5 States that have designated rivers, have been minimal. In total, only 7 of the 23 physiographic sections of the northeast are represented by State rivers. Almost all of the State designated rivers are medium or small size rivers -- the Potomac and Pataxent Rivers in Maryland and the Hudson River in New York being the only exceptions.

State river programs with several exceptions generally either do not exist -- as is the case in the States of New Hampshire, Vermont, Maine, Connecticut, Rhode Island and Delaware -- or are often poorly budgeted, staffed and lack a vigorous implementation element -- as is the current situation in Massachusetts, New York, Virginia, and Maryland.

The implications of this situation at the state level is compounded when one realizes that over half of the States within the northeast regional area do not have wild and scenic river programs. River segments identified within these areas represent 28% of all the river miles recognized or nearly 1,500 miles. Over 70% of all the physiographic sections within the northeast -- with representative rivers in each -- are within these States.

Of the six States which do have wild and scenic river programs, one -- New Jersey -- has yet to officially designate any rivers, although it is in the process.

In Maryland, the 9 designated rivers which comprise approximately 442 miles, flow within the Embayed, Piedmont Upland, Piedmont Lowland, Northern, and Allegheny Mountain sections.

New York's designated rivers fall into two distinct categories -- those within the Adirondack Park and those outside that area. Within the significantly state-owned Adirondack Park, nearly 1,200 miles of rivers have been designated. Outside of the Park, in the remainder of the State, approximately 16 miles of rivers have been designated. Virtually all of the nearly 68 designated rivers in the Park flow within the Adirondack Province, while the 16 designated miles on 2 rivers outside of the area are within the Embayed section.

Pennsylvania's only designated river, approximately 93 miles in length, is the diverse, semi-urban Schuylkill River which flows within the Piedmont Upland section.

West Virginia's 5 designated rivers, totaling 205 miles all flow in close proximity to each other within the Kanawha Section and each offers a variety of whitewater characteristics.

Virginia's approximately 100 miles of 6 designated rivers all flow within the Piedmont Upland Section of the state and generally tend to be a combination of relatively short segments and comparatively small sized rivers.

The oldest state designated river in the northeast is the Allagash River in Maine and is 92 miles in length. Maine, which does not have a rivers program, designated the Allagash prior to applying for, and receiving federal designation as a state administered national river. No other river besides the Allagash in the northeast has received both State and Federal river designation.

Unfortunately, more free-flowing rivers in the northeast are threatened than are protected. Each of the 171 free-flowing, relatively undeveloped river segments in the northeast region, which were examined in detail, is threatened by some form of adverse land use development. More specifically, nearly 2,000 miles of the rivers identified are presently planned for some form of non-conservation land and water use which would have a significant negative impact on river values. Existing and proposed developments that are impacting and could change the free-flowing, undeveloped and outstanding character of these rivers and river segments range from such massive land uses as nuclear power and hydro-electric plants, flood control dams, and reservoirs to minor land uses such as sand borrow pits, second home developments, logging, channelization and private recreation development.

The most common "threats" to undeveloped and free-flowing rivers in the northeast region are water supply projects and flood control dams which immediately threaten the condition of approximately 640 miles -- or 11% -- of all the rivers identified. Not surprisingly, the majority of the known projects or activities that presently threaten the rivers identified, occur within the Embayed, Piedmont Upland and New England Upland physiographic sections -- those sections with the most undeveloped, free-flowing river mileage -- of the northeast.

The characteristics of the river corridors within each physiographic section will dictate the types of less-than-fee acquisition strategies which will be appropriate to use to conserve a river. Certain physiographic sections and river corridors are more amenable to certain types of strategies than others and no one conservation approach is suitable regionwide.

Rivers and river corridors within most of the rugged, steep and mountainous physiographic areas, such as the Adirondack Province, White Mountain and Green Mountain sections, due to the topography and the land development within the narrow river corridors, are amenable to specific conservation strategies such as special historic and aesthetic districts, national and state historic landmark status, scenic view-shed ordinances, building setbacks, and scenic highway designations.

In those sections dominated by wetlands, high water tables and floodplains, such as the Embayed, Piedmont Upland and New England Upland physiographic sections, conservation strategies such as wetland regulations, floodplain zoning, rare and endangered plant and animal designation, shoreland zoning, and critical areas protection are appropriate.

VIII. Implementation Options for Greenway Conservation

The National Wild and Scenic Rivers Act, the Nationwide Rivers Inventory and other river conservation strategies have already been used in various ways to achieve greenway conservation. The following examples that are briefly highlighted are some general and conceptual examples of approaches which can be used to conserve an area. More specific and detailed stormwater management alternatives which cover a full range of planning, design, implementation, management and construction approaches can be used in concert with these strategies to initiate and implement greenway programs. Each approach can be used to sell the concept of blue-green technology as well as minimizing any environmental impacts to stream valleys.

Case Study Examples of Greenway Conservation

1. Using the provisions of Section 2(a)(1) of the Wild and Scenic Rivers Act in 1979 Congress, as part of the National Parks and Recreation Bill, designated the Middle Delaware River in N.J. and PA., a National Wild and Scenic River. Located approximately two hours from New York and Philadelphia, the Middle Delaware is one of 22 in the National System.

2. The Department of Interior's National Park Service, in coop-

eration with the State of Connecticut and regional and local governm-ments has proposed that the Housatonic River, 60 miles from New York City, be designated a National River to be managed by State and local governments in that area. At this moment, local governments and private citizens are preparing a plan using funds from the National Park Service to determine how this river will be used and managed in the future.

3. In 1970 and 1976, the Secretary of the Interior exercised the provisions of the Act and identified 78 rivers flowing within 24 States as 5(d) rivers. This recognition has helped to insure Federal program coordination and to minimize adverse environmental impact to these nationally significant rivers. Recently in the President's 1979 Message on the Environment, Federal agencies were further directed to avoid any adverse environmental impacts to all of the rivers identified by HCRS's Rivers Inventory. In the northeast region alone this means that 171 rivers and river segments, comprising over 5,308 miles have been afforded a minimum amount of protection. By early 1980 at least another 5 to 10,000 river miles in the northeast will be added to that list.

4. The river information gathered during the Inventory has also been used to indirectly help achieve greenway conservation. Whether it is for better or for worse, the numbers game is essential in all aspects of environmental protection. Without the facts, the statistics, the "conservation argument" is vulnerable.

5. Proposed legislation for a National Heritage Program was sent to Congress in September from the Department of the Interior. If enacted, the legislation would establish a National Register of Natural Areas, and it would expand the existing National Register of Historic Places. The new register would include natural sites ranging from land forms, rivers and estuaries, to plant and animal communities. Listed heritage areas would receive various means of protection. For example, Federal agencies would be required to assess the impact of contemplated actions, and avoid adverse impacts. Developers of energy facilities or other major projects would also be alerted to avoid damage to registered sites.

This legislation would also make limited funds available to participating States and establish a Heritage Conservation Council to advise the President and Congress on matters related to environmental conservation.

6. There has been widespread and growing interest in urban waterfronts, as areas which can both enhance commercial redevelopment and provide accessible recreation in an urban landscape. In response to this, HCRS has launched an Urban Waterfront Program, for the purpose of bringing together such diverse groups as the EPA, OCZM, urban planners, and recreation planners, to exchange their insights and experience, with the hope that parks and clean water in an urban environment will help generate housing, greenways, jobs, revenue and other future benefits.

7. In 368 certain selected urban areas nationwide funds are available, through HCRS, from the National Parks and Recreation Act

of 1978. More commonly known as the Urban Park and Recreation Recovery Program, P.L. 95-625 was established to assist communities to preserve and upgrade existing park and recreational facilities. Funding for this five year program nationally has been authorized by Congress at a level of $180 million annually for the first four years and 125 million for the last year. Grant monies are available for:

1) the rehabilitation of existing outdoor and indoor recreation areas and facilities

2) Innovative projects to demonstrate the use of personnel, facilities, equipment, supplies and services

3) and for Recovery action park and recreation system development.

Activities that may be undertaken include resource and need assessments, citizen involvement, coordination and program development.

8. The Land and Water Conservation Fund, also administered by HCRS, is the major source of assistance to increase outdoor recreation and open space opportunities. Funds are available through State governments to their political subdivisions for the acquisition and development of public outdoor recreation areas and facilities. Project grants must be matched by not less than an equal amount of non-Federal funds. This year over 369 million dollars were authorized nationwide under this Fund.

9. Before a State can receive Land and Water Conservation Fund money, it must have a current plan which describes ways which the State will help satisfy recreation and open space needs at all levels of government. This plan is called the Statewide Comprehensive Outdoor Recreation Plan referred to as the (SCORP). Each State is encouraged to hold meetings throughout the State so that the public can help develop and review their State's recreation policy. This plan and the process is important because it will reflect the Governor's policy on recreation and open space and will establish priorities for distribution of recreation and open space conservation funds.

10. In Boston, Massachusetts, the U.S. Army Corps of Engineers has recognized the wetland areas adjacent to the Charles River as invaluable natural storage areas for storm waters. Approximately 8,500 acres of wetlands are planned for acquisition or restrictive easement protection under the Corps' Natural Valley Storage Area program that is now underway. Acquisition of these wetlands was authorized by Congress in the 1974 Water Resources Development Act (P.L. 93-251), which requires all flood control studies to consider non-structural projects.

11. The Passaic River is a diverse greenway which extends from the heavily urbanized areas of Passaic, N.J. to the rolling farmed and forested hills of Morris County. The Passaic River Coalition, an active citizens group in northern N.J., is currently petitioning the EPA to have this area designated as Sole or Principal Source Acquifier Area under the Safe Drinking Water Act (P.L. 93-523). Section 1424(e)

of this legislation, if authorized, would insure the review of all Federally financially assisted projects to avoid contamination of the acquifer.

12. A county zoning ordinance was the mechanism used by residents near Deer Creek, in Harford County, Maryland, to restrict streambank development and to create a permanent watchdog committee that reviews proposed changes in land or water use within the stream valley. This ordinance was developed as an outgrowth of a management plan prepared for Deer Creek through the Maryland State Scenic River Act.

13. New York State's Department of Environmental Conservation, in recognition of the need for "grass-roots" greenway conservation involvement and support, has developed a Manual of Guidelines for Conducting River Studies. Prepared in cooperation with HCRS, the manual was developed for use by local governments and citizens and describes greenway conservation alternatives using N.Y.'s Wild, Scenic and Recreation Rivers law and various existing local government regulations and programs.

14. In 1973, the State of Georgia passed a Metropolitan River Protection Act for the purpose of ensuring adequate supplies of clean drinking water to the large metropolitan areas of the State. This is being accomplished through a Commission, created for the Atlanta metropolitan area, and which has responsibility for writing comprehensive land and water use plans in consultation with local subdivisions in the Atlanta metro area. The Commission also has authority to use police power to discourage harmful construction or any activities not in compliance with the plan, and to evaluate and direct land and water planning carried out by local subdivisions.

15. Established by State law in 1978, the North River Commission in Massachusetts, represents the governing bodies of 6 towns along the river. The Commission has the responsibility of preparing a river management plan, of issuing and reviewing permits, and enforcing the provisions of the Commission. This approach to greenway conservation is especially impressive considering that the river corridor, which is virtually undeveloped, is only 25 miles from Center City Boston.

16. The New York Planning Commission has successfully achieved greenway conservation using special zoning regulations. Through the use of local police powers and by creating conservation incentives for private developers, the City has established Special Natural Area Districts to protect, among others, aquatic features such as creeks, brooks, streams, lakes, tidal wetlands, swamps, marsh, bogs and meadows. The City's regulations emphasize the protection, maintenance and public use of these areas.

17. The Winooski Valley Park District in Vermont provides another model worthy of serious consideration for local greenway conservation. This district, organized under Vermont State law by a group of municipal governments along a river valley, provides for a union Winooski Valley Park District to plan and administer public parks and "the preservation of natural areas." The District has the power to acquire land, either in fee ownership or any lesser interest, together with the

right to manage and regulate the use of any land in which it holds any type of interest, by controlling access and by prohibiting certain uses of land.

18. In Connecticut, eight Towns along the Housatonic River each adopted a uniform ordinance in which they agreed to maintain uniform standards for land and water use locally under the coordinating surveillance of a permanent Housatonic River Advisory Commission. The ordinance provide protection for the varied natural resources and scenic qualities of the river corridor by ensuring floodplain protection, restricting land use in the valley, and encouraging the establishment of easements and land trusts.

19. The Saco River corridor includes nearly 300 miles of riverfront in Maine which has been protected from haphazard development by the actions of a group of local citizens. Their plan led to formation of a River Corridor Commission, a regulatory agency made up of citizens who issue permits for construction and development in accordance with General Performance Standards which they designed. The Standards include restrictions on land clearing and waterway construction; they prohibit sewage disposal in the 100 year floodplain; and they require building setbacks which are based on river frontage, broad frontage, and lot size.

20. The Bronx River Restoration Committee in New York recently completed a master plan, funded by grants from New York State, the National Endowment for the Arts and private foundations. The plan, now being implemented has four specific objectives. The first is revitalization of the Bronx River and its banks, including water quality improvement. A second objective is the development of potential social, cultural, educational, and recreation aspects of the river. The third objective is the employment of local youths and adults in the creation of open spaces and programs along the river. Finally, opportunities for small business development will be opened. The master plan stresses community development in its program and the use of Federal funding programs from the Small Business Administration, the Economic Development Administration and the Department of Labor.

IX. Summary

In conclusion, stream valleys are extremely diverse, sensitive and complex places. Although river and stream conservation is often perceived as recreationally oriented, greenways can achieve numerous other objectives. Stormwater management is one important example. Prior to initiating any actions in river corridors, planners should fully understand the various natural, physical, and social processes which take place there. Planners should also consider that different uses of the river and its corridor require different approaches to management and conservation. Equal emphasis can be given toward understanding the land and water resources, the people who live within and use the area, the issues relevant to the corridor and its future use and the institutions and techniques which can be used to achieve the conservation of these valuable areas.

23

SPECIAL DISTRICTS FOR THE MANAGEMENT OF ENVIRONMENTAL QUALITY

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Introduction

The field of environmental analysis and policy covers an extremely wide range. At one limit lies the bio-physical nature and behavior of the world we live in. The character of land, of slopes, of soils, of water, of bio-aquatic life must be understood. Presumably this understanding will give us clues as to how best to use the natural resource system that surrounds us and from which we gain most life supports. Over at this limit we find physical scientists and engineers at work.

At a second limit are the manmade laws, institutions, regulations and standards that we put into place to guide the technology we use to gain access to the resource base. This technology takes the shape that our institutions and laws allow it to have, no more, no less. What we allow as permissible technology depends on our goals. But not on our goals alone. What actually happens in the interface between earth moving equipment and streams, between chemical fertilizers and fish life, for examples, depends on how our institutions and laws affect our behaviors. What counts is not what institutions and laws are "supposed" to do, but what people actually do. Over at this second pole, or limit, we find social scientists working.

What mattered for people in American cities is not what the War on Poverty, minimum wage laws or urban renewal laws were supposed to do but what they actually did do.

What matters for people and firms in the Delaware Valley is not what the Delaware River Basin Compact is supposed to do but what it actually does do.

When our laws or institutions allow increases in the tyranny of non-convivial technology -- and when our laws and institutions fail to bring about resource uses that are less costly and more beneficial than we are capable of, then we must rebuild either the laws the institutions . . . either that or we become poorer.

One great challenge of course is to be able to recognize how costly and how beneficial an institution like the market that facilitates resource uses and investment in technology is; to recognize how costly and how beneficial specific regulations are, how costly and how beneficial programs like 208 are. What we know is, of course, that markets partly fail, that regulations partly fail and that programs like 208 partly fail. What causes these policy failures?

Each of these institutional elements fail or fall short, in great part, because of the behaviors of people.

It is the response of people in markets to shaky property rights in the air or in water that explains much urban congestion and pollution.

Behaviors of people, both the regulators and the regulatees, lead regulations to be ineffective or less effective. It is the response of people, in the private sector, in governments and in agencies like 208 that leave this or other environmental programs short of their objectives.

There is no technological fix for the environments, nor will there be a fix through the market, through regulation or through institutions unless human behavior is brought into policy making.

The behavior of man, or explicit recognition of man's behavior, is the essential ingredient for effective environmental policy. Nature alone makes little pollution. Technology without man can do nothing. Because small area Special Districts could focus attention (both technical and social) closer to man and closer to the environment, Special Districts promise to be institutions that could deliver better environmental outcomes.

Small area scale would be important since, if responsibility of the District were localized, direct sensitivity to the behaviors of farmers, of builders and of factories in the area could be developed. Whatever policy mix the Special District followed (prices, regulations or direct provision of some services), results could be more easily evaluated since the people served by the District can be directly known and can make themselves known at low costs.

The scope of resource management for an environmental Special District would, at least, cover aspects of water and land, since many of the most troublesome issues, such as soil erosion and storm drainage, are joint water-land issues. Moreover, some of the promising benefits such as expanding recreational (hiking, biking and fishing) programs would usually involve water and land.

What are some possibly useful ways to look at Special Districts? One is from the field called Public Choice. To form Special Districts for Environmental Management the present structure of governmental units must be changed in some particular sub-area. The coming of the Special District means that the spatial boundaries of existing governmental units must be shifted. The functions some governments may already seem to perform, and revenue gathering powers to support the Special District, may have to be shared.

James Buchanan and other political economists have developed a theory called fiscal clubs in order to understand the implications local government boundaries may have on public good provision and use. This theory of fiscal clubs may be relevant to Special Districts for environmental management because an immediate practical issue facing this kind of institutional innovation is political feasibility. A second issue is expected operational performance. How can we estimate relationships between institutional structure and human behaviors toward the environment? This is the question we are interested in and for which the theory of fiscal clubs gives insight.

Why Set Up Special Districts?

Local government clubs frequently come into conflicts of interest with one another, do not offset negative externalities in the private sector or simply fail to produce all the potential positive externalities they might. Trade or exchange between fixed governmental clubs is difficult. To rearrange club boundaries or responsibilities frequently requires that the interests (streams of expected costs and benefits) of many corporate and household persons be taken into account. The costs of negotiating an acceptable set of boundaries for a new club like a proposed Special District and of defining the new responsibilities and linkages to the existing government clubs are potentially quite high. The incentives to the officials who must engage in these complex transactions are probably weak. Nevertheless the environmental management benefits to the client citizens might, in many cases, exceed the costs of organizing and managing the Special District. Unfortunately, high net benefits to many citizens do not in any way assure the public officials in charge of the present club arrangements that they, personally, may not lose. Indeed to reduce bureaucratic scope and size can be shown to reduce the welfare of public officials. Bureau size, in itself, is (like profits in a firm) something public officials strive to expand since bureau size is related to official prestige and income.

The challenge facing those who believe that environmental management can be more efficiently carried out by Special Districts is to develop reliable ways (theory, methods and measures) to determine that Special District Clubs can provide environmental services more effectively . . . and secondly, devise legal procedures that will reduce the political resistance costs of forming Special Districts.

Theoretically five distinct effects of forming a Special District can be anticipated and must be considered.

a) The size of populations being served public goods outputs (in this case, environmental services only) will be modified; not only in the new "Special District," but in the older pre-existing government arrangement.

b) Negative externalities that had existed can be reduced and positive externalities which had not been realized by the previous structure may be increased but the policies of the Special District, not just the existence of the district will play an important role.

c) Coalitions of preferences by corporate or household citizens in the Special District and in the older governmental units for environmental services may change once the District forms; presumably the costs to people of articulating these preferences in both areas can be lowered.

d) The potential for technological innovations may be raised. First because a better fit between citizen goals and technical options can or must now be made. Second because, as governments tend to compete and to serve different citizen groups, entry of small scale technology may be enhanced.

e) The unit costs (average and marginal) of delivering environmental services may be changed.

One argument for the Special District is that environmental services become the specialized objective of the newly formed government. Specialization or focus only on environmental services, may lead to lower cost ways of delivering intended environmental benefits. In general, this has tended to happen in most areas (public or private) where specialization was possible. Of course specialization has costs as well, and these must be balanced against intended or actual benefits.

Special Districts are institutional innovations. Potentially, SD's allow people to arrange themselves for improved joint consumption or production of certain services.

This re-arrangement is necessary because a) markets privately organized fail to provide the services well or at all, and/or b) governments as organized fail to provide the kinds and qualities of services that people want and that are feasible.

The legal nature of a Special District amounts to a multi-person contract to provide certain services. As with all governments the police power of the state is needed to enforce or secure the rights of the Special District once it is formed and operating.

Members of the Special District club are the people in its service area and, in the least, they are free to leave or enter, invest or disinvest in privately held property within the club boundaries.

In an open society non-members (people from other areas) are also free to visit or to invest in the area. A question to be faced by environmental management districts is how the supposed superior environmental services are to be allocated among residents of the District and "outsiders," who may visit to enjoy the improved services (use the "nature" trails). Congestion, or rates of use that exceed environmental capacity, will lower service performance benefits and perhaps inflict increased maintenance costs on the Special District. It can be expected that rationing devices ranging from club membership cards to user prices may be necessary if either marginal costs of providing some environmental services are positive or if crowding sets in.

The troublesome characteristics of so-called public goods cannot be expected to go away once a Special District is formed. Technically, economists identify these troublesome characteristics with the indivisibility and non-excludable nature of public goods. The former feature, indivisibility, means more than one person can feasibly consume these services at the same time and usually does. All lands in a district may drain into the stream in a rainstorm. Nonexcludability means some drainage services cannot be economically organized so that non-purchasers are excluded from benefiting.

Members of the Special District club will have to tend to the development of allocation rules that steer or channel both benefits and costs to themselves and to their visitors so that efficient use of the environment results. Whatever steering devices are used, and one of many would be fees, distributional consequences will result. Some people may get more or better services than others.

Theoretically, the utility citizen club members can expect from environmental services is a function both of the amounts of services produced, E_o, and the number of members, C_m, or non-club members, N_m, sharing the service outputs.

$$U = U\ (E_o,\ C_m,\ N_m)$$

There is a literature in economics where the issues of the utilities people derive from public goods are joined with the characteristics of rationing devices. This literature explores the implications for users and for rates of use; moreover topics, important to the Special District and its continued existence, such as revenue and cost streams, are also considered. Suffice to say here that the size of the membership plays an important role in both the net benefits any individual member-resident of the Special District can expect and the overall fiscal viability of the District.

Special Districts for Environmental Services delivery probably can provide exciting and convivial mixes of products that are now overlooked. The benefits of these services may well run far ahead of the costs . . . at least on the drawing board. To get beyond the drawing board it will be necessary to face up to the preferences of club members for environmental services produced and to who uses and who pays for the services. As the number of people in any Special District rises, the likelihood that preference agreement can be reached on the proper mix of environmental services to produce falls. This fact argues for relatively small special districts and also tends to explain why large area environmental programs have weak support except among supply side technocrats. But as the size of a Special District shrinks, the potentials to internalize environmental externalities, one of the key supply side arguments favoring Special Districts, becomes weaker and weaker.

Like every other policy move in the natural resource management area, Special Districts are not going to be a costless, nor an everywhere useful panacea. Farmers, firms, estates and householders located within a potential Special District can reliably be expected to have differing preferences for bundles of environmental services. Special Districts would seem to have the greatest likelihood for success when service preferences among District residents are nearly homogeneous. Voting rules by citizen members for both the Special District managers and for investments or programs will be an important feature of the "club" by which supply and demand differences and changes over time get worked out.

This treatment of the political economy of Special Districts is not complete but hopefully the outlines of how the theory of fiscal clubs can help identify important policy issues for Special Districts have been sketched.

Why Markets Fail and Collective Signals Are Needed

Microeconomic theory established some general principles and conditions under which people can use scarce resources and achieve satisfactory results. In this important body of theory, with wide applications to resource management, the nature of production functions, of cost functions and, most importantly the role of exchange between persons (or firms) as users or providers of services are highly developed.

Guidelines for managing the environment of a local area also can emerge from micro theory analysis. One guideline for policy or management is that it can be reliably shown that, under certain conditions, resource usage or exchanges by persons will not lead to socially efficient outcomes. This breakdown of private exchanges by which many resource uses and investments are organized is called, simply enough, "market failure." Pollution of various forms, as well as congestion, are day to day words used to describe market failures. Producers of goods or services who use land, water and other resources have little reason to economize or manage resources efficiently whenever resources are held in common as are rivers or the atmosphere. Farmers, chemical factories, government agencies and ordinary households, in both capitalist or communist systems, tend to pollute whenever property resource assignments are weak or unclear. The average farmer, for example, has strong incentives to grow this year's crops in a way that does not damage the value and productivity of his land for the following year. Farmers typically do not intentionally pollute their land which would lower their own wealth, raise the direct costs of farming, or both. But farmers, factories, real estate developers, or any of us for that matter, reliably cause or permit common pool resources, like air and water, which none of us own directly, to become degraded. When degrading uses of resources reach a volume or occur in a way that outruns nature's recuperative powers, pollution sets in.

In a sense, the economics of market failure suggests that individual incentives for effective resource management will not be adequate when common property resources are used intensively or insensitively. The important policy inference is that, since acting in our own interests yields bad results, we need to take some collective action. What we need to do is simple enough to describe: we need to send ourselves signals that will lead us to revalue and then change some of our actions. The signals which collective action devises should lead us to stop imposing damages on others on the one hand, and guide us into convivial or benefit-reinforcing behaviors. Not just any signals will do. The signals we want should also be those that are inexpensive to design and to manage. Special Districts could devise such signals.

Conclusion

Special Districts for environmental management have the potential to be the kind of institutions that will be able to balance human behaviors and preferences, technology and the sometimes fragile, sometimes highly interrelated nature of the environment.

Responsibility and authority to manage resources in a way that fits with people, technology and the environment must be clearly assigned to the Special District. This will require decisive legal and political action.

The services, regulations and programs of the Special District will require human and financial resources. But if the Special District creates benefits that outrun costs, District residents can gain. Service charges will have a great deal to do with both who gets the benefits or whether the District will have the ability pay for necessary management and infrastructure.

The promise and the puzzles of Special Districts seem real enough. Over the next couple of years we, here in Delaware, will probably experience more of each as we explore a Special District for stormwater management along the White Clay Creek.

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THE UNCOUNTED COSTS OF UNCONTROLLED WATER

MARSHALL HAWS

Chester County Conservation District, West Chester, PA

Can we assume that the final objective of all ordinances, laws, rules and regulations is to provide justice for individuals?

Damages and restitution are awarded to a person when his physical body is damaged -- when he is unable to use any part of it. Since property is the extension of a person's life and actions, it makes sense to provide justice to a person whenever his property is damaged and he is prevented from using it (e.g., automobile damage). It also seems reasonable that a property owner should be paid damages or restitution for problems caused by increased flow of water from an upstream property as a result of the actions of the owner of the upstream property or his agents.

Ordinances and Laws

In most cases the property owner wants present and future damages stopped. The property owner wants solutions to his problem of increased runoff. Ordinances and laws talk in terms of permits, plans, penalties to be paid to the state, jail terms, and strike force. Nothing is ever said about making the property "whole" again, or making restitution to the owner of the property that was damaged.

Rules and regulations, ordinances, laws -- in short, government -- have not been able to provide the solutions because:

1. The "book" doesn't cover the situation.
2. There is a lack of knowledgeable manpower to follow up on complaints.
3. Government solutions are rigid, following a predetermined course of action and making no attempt to find solutions.
4. Government is too far away to be familiar with the situation (except for the possibility of local government).

Our present system of justice (the courts system) is less than effective for several reasons. It can sometimes take from three to seven years to get a case into court because of scheduling conflicts, continuances and other delays. Because of the time lag, witnesses may be unavailable when the case does go to court. Lawyers' and court fees can add up until the property owner is unable to afford the cost of justice. Court decisions are based on precedents or lack of same, not on justice. Judges and juries may not be familiar with the factors involved with uncontrolled water. The adversary situation makes it difficult to bring out facts and understanding. Judges seem to base their decisions on what the potential of the decision may be rather than providing justice to the owner of the damaged property.

Arbitration

Arbitration could be used as a system to provide justice for the owner of the damaged property. There are several advantages to using this method to provide solutions. Arbitration could work much faster and less expensively than other forms of justice. By bringing the complaint and the alleged creator of the problem together before the problem became unmanageable, arbitration would reduce or eliminate the adversary position between property owners. Most developers would much prefer to create good relations with their neighbors than to be involved in litigation.

The implementation of an arbitration program should take place at the lowest level of government; i.e., township, municipality or county. The following outline suggests the items that such a program would contain. Hopefully, older and more perceptive heads would add anything that I may have missed.

D O C U M E N T

________________________ Township

A landowner or a resident thereon, in __________________ Township, __________________ County, will not be permitted to damage his neighbor's property by:

1) Permitting silt and sediment from earthmoving operations to cross over or collect upon neighboring property(ies).

2) Permitting increased water runoff caused by changes in the use of his land or land topography to exceed that runoff which existed under original, natural conditions[1]:

    A) That causes erosion or gulleying on neighboring land (soil)

    B) That creates deposition of silt on neighboring property(ies)

    C) That creates pockets of water or wet conditions on neighboring property

    D) That causes a lowering of the water table in the area

3) Collecting (concentrating) water and releasing it at a rate exceeding that rate which existed at that point previous to the collection and concentration procedure.

Any landowner, resident, rentor, and/or leasor of property which either by accident or design, creates any or all of the above damages to neighboring property(ies) will put to right (correct such damage) within (24)(48)(72) hours.

In addition the landowner, rentor, resident and/or lessor of such property causing damage will make restitution to the damaged property owner(s) resident, rentor and/or lessor:

1) either by mutually agreed upon compensation or

2) compensation as determined by an arbitration hearing board comprised of three (or more) members.

Such an arbitration hearing board will be determined as follows:

1) A list of possible arbitrators will be presented to the disputants for their deletion of any individual not satisfactory to either of them as a member of such an arbitration hearing board.
   A) This arbitrator list will be comprised of one supervisor (and/or planning commission member) from each township in the county, serving on the list either by appointment from his township or volunteering from his township.
   B) The arbitrator list to be compiled by the county association of township supervisors.

2) A representative from the county association of township supervisors will select at least three members (on a rotating basis) for the arbitration hearing board from the list that has been indicated as satisfactory to both disputants.

A decision of this arbitration hearing board could be appealed to a recognized arbitration organization. The decision reached by that organization would be legal and binding. Either disputant dissatisfied with the arbitration decision could take the case to civil court.

Penalties[2] for permitting the above damage, caused by the activities but not corrected and/or restitution made to the damaged property owner(s) will be assessed as follows:

1) $____________ for each occurrence.

2) $____________ per day for continuing conditions which caused the original damage.

If the township supervisors (or their designees[3]) of ____________ Township find that the damage results from an act of God[4] in either the form of sediment of increased runoff from land for which a complete erosion/sediment and storm water management plan[5] has been developed and the plan has been fully implemented and maintained, the landowner, resident, rentor and/or lessor shall be excluded from the penalties of this act.

NOTES:

[1]It may be necessary to define "original, natural conditions." One suggestion is that it be those conditions that existed before development, i.e., original, natural vegetative cover. The Chester County Conservation District used the definition "good meadow, good woods" as shown in the U.S.D.A. Soil Conservation Service engineering manual.

[2]Penalties might be distributed:

(3/4, 7/8, 31/32, etc.) to property owner

(1/4, 1/8, 1/32, etc.) to township

These would compensate the property owner for damage and compensate the township for any expenses involved over a period of time.

Expenses of arbitrators would be assessed by arbitrators to either or both disputants.

[3]Designee(s) may be (1) chosen by the township supervisors, (2) a selected arbitrator, or (3) the arbitration hearing board.

[4]It may be necessary to define the type of storm that would be considered "an act of God." (Chester County uses a 100 year storm, defined as 7.2 inches of rain in 24 hours. Perhaps this definition should be based on shorter duration, higher intensity storms.)

[5]It may be necessary to define under what conditions a "complete conservation plan" should be considered "adequate."

Procedures for Arbitration

When township supervisors or municipal officials are approving subdivision plans, they will include a clause in the approval that contains the necessary provisions for immediate arbitration of a complaint received from the owner of damaged property. The clause will contain the following stipulations:

1) The developer agrees to answer any and all written complaints from township residents alleging that the actions of the developer and/or his agents on his property are damaging their property, and agrees to follow arbitration procedures if requested.

2) The developer agrees to answer such complaints within five days from the time that the township receives the written complaint from the

complainant and notifies the developer by telephone with written confirmation; with a copy to the complainant and to the file.

3) At the end of five days, if the complainant is not satisfied that the damage to his property has been adequately taken care of or if the developer feels that the alleged damage is not his responsibility, the township will forward an arbitrators list to both parties. This list is to be returned in three days.

4) The disputants would cross off the names of any person that they would not accept on a panel hearing this dispute.

5) A list not returned from either party would indicate that all arbitrators would be acceptable to that party.

6) The township would either:

A) Forward the accepted lists to the county association of township supervisors for the association to select three arbitrators (on a rotating basis) or

B) The township would select three arbitrators.

7) The township would notify the arbitrators and work up an acceptable time and place for a hearing.

8) Either party might be permitted one postponement.

9) Either or both parties could present their own case to the hearing board. This could be done by description, pictures, witnesses and/or visiting the property.

10) A decision from the arbitration hearing board might include recommendations for correcting the problem, cleaning up any damages, and establishing restitution for damages, in time and amount.

11) Any actions mandated by the hearing board must be carried out in a specified length of time. This would be written into the decision.

12) The costs of the arbitration proceedings could be prorated between the two disputants. The township may feel that it has supplied sufficient service by taking care of the notification and book-work procedures. Or the township might stand a portion of the costs, the same as it now pays for a police force and the court system.

13) The arbitration system of justice would permit the township to fulfill its function of protecting the private property of its residents, providing the function with efficiency and relative low cost.

14) It would eliminate the necessity of municipal officials making laws and then enforcing those same laws. It would take the supervisors out of the middle of sticky decisions. It would save all parties concerned considerable time and harassment.

For further information on arbitration:

Fucetola, Schetlick, DeBlock & Stein, Limited
Private Mediators and Arbitors
23 River Road
North Arlington, NJ 07032

American Arbitration Association
140 West 51st Street
New York, NY 10020

HOW -- Home Owners Warranty
from your nearest Home Builders Association

Carl E. Person
National Private Court
132 Nassau Street
New York, NY 10038

Conclusions

Each property owner is in the best position to recognize and evaluate when his property is being damaged by increased stormwater runoff, erosion or sediment.

We have policemen to apprehend individuals who commit criminal damage to our property. Where is the policeman that we call when increased runoff and resulting mud and sediment is damaging our property?

Present methods of stopping this damage to private property are:

A) Appealing to government to stop the damage, e.g., supervisors, Department of Environmental Concerns, health department, etc. This takes time and is not very effective -- too little, too late.

B) Eventually bringing civil suit. This takes a long time, and the judge bases his decision on law, not justice. Legal costs in most cases are prohibitive.

Arbitration procedure could bring the owner of damaged property and the alleged creator of the problem together in a few days.

If the disputants were unable to reach an agreement, facts would be presented to a fact-finding panel. Mediation during the process could permit other possible solutions to the problem.

The decision of an arbitration board would be based on justice, not rules and regulations.

The process of arbitration would be educational for the arbitrators on the panel. With municipal officials as arbitrators, the facts presented could be applied when reviewing sub-division plans for similar problems in their home communities.

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PUBLIC PARTICIPATION IN ANNE ARUNDEL COUNTY'S WATER SHED MANAGEMENT PROGRAM

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Anne Arundel County, Maryland has recently started a Watershed Management Program that has incorporated citizen involvement in all stages of the program. Citizens have participated in the identification of the study area, the development of the work program and the selection of consultants. For the first watershed considered, Severn Run, citizens have been involved throughout the study including review of all draft documents. This approach to comprehensive public involvement from the start of a study and particularly a major County wide watershed management program, is unique within the Baltimore-Washington region.

Background

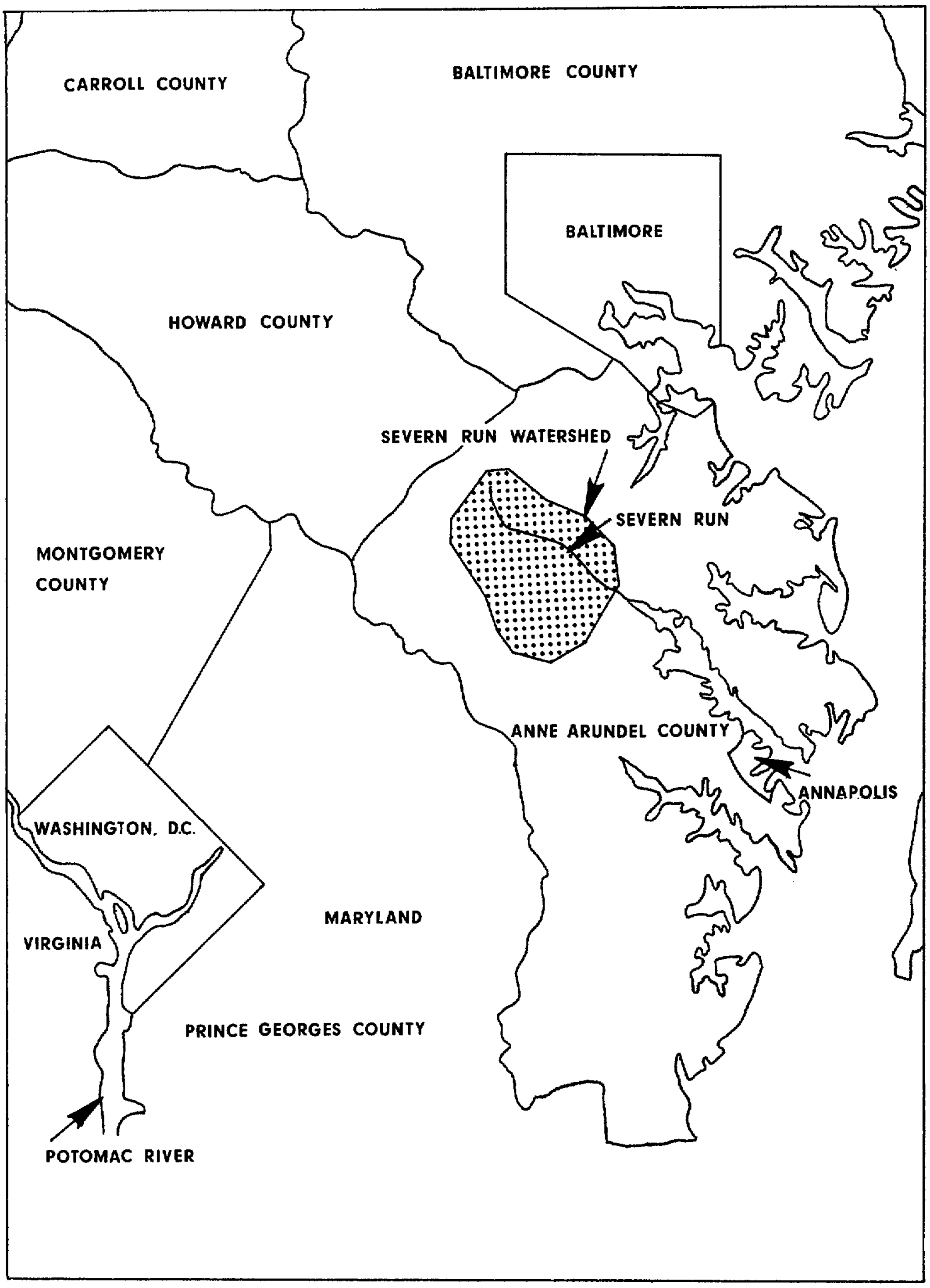
Anne Arundel County, Maryland, is a rapidly growing county with a 1978 population of 373,560. It is located along the fringes of the Washington, D.C. and Baltimore, Maryland metropolitan areas (Figure 1). Contributing to the County's attractiveness for development is its 431 mile coastline along Chesapeake Bay and the importance of the state capital in Annapolis. There are nine major watersheds that drain the County eastward to the Chesapeake Bay.

In 1972 Anne Arundel County, recognizing the need for effective management of urban storm runoff, established by County Council resolution a Stormwater Management Task Force whose responsibility was to design a framework for systematic analysis of watersheds within the County. This analysis included identification of problems, possible solutions and priorities and the development of standards, specifications and procedures to be implemented. Further consideration included guidance of development and implementation of comprehensive stormwater management master plans, land use analysis and recommendations for legislation necessary to implement a stormwater management program.

This Stormwater Management Task Force was composed of representatives from County and State agencies, citizens involved in environmental groups and private interest groups. During this time a Technical Advisory Committee (composed of engineers, developers, County and State representatives and civic associations) was formed to aid the task force in defining appropriate criteria for on-site stormwater management. The combined efforts of these two committees culminated in the passage of the County's Stormwater Management Ordinance in 1977.

After the passage of the Stormwater Management Ordinance, Anne Arundel County took a second step toward developing a watershed management program by allocating money to conduct a comprehensive watershed study. The County, recognizing the importance of citizen involvement in the earliest stages of planning, rejuvenated the Stormwater Manage-

FIGURE 1: General Location Map



ment Task Force in the form of two committees, a Citizen's Advisory Committee and a Technical Advisory Committee. Both included members from the previous Stormwater Management Task Force. The committees were responsible for selecting a watershed to be studied, developing a scope of services for the study, and were involved in selection of the consulting firm to conduct the study.

Severn Run Watershed Management Study

The Severn Run Watershed is located in the northwestern portion of Anne Arundel County, Maryland (Figure 1). The watershed is approximately 4 miles south of Baltimore-Washington International Airport, 14 miles northwest of Annapolis, and 23 miles northeast of Washington, D.C. Severn Run is the primary source of fresh water inflow to the Severn River, a tidal estuary of the Chesapeake Bay. Severn Run watershed has an area of approximately 24.2 square miles or 15,500 acres.

The Severn Run Watershed Management Study was initiated to identify stormwater problems and opportunities for enhancement of the Severn Run Basin. This study was to act as a prototype study and identify watershed management concerns on a county wide basis.

As a result of a series of meetings in late 1976 and early 1977, it was decided that Severn Run would be the first watershed for a comprehensive study. In February of 1977 the "Request for Proposal" was initiated with various County departments being requested for input. This group effort was desired so that a broad spectrum of concerns would be incorporated into the proposed work plan.

In March 1977, a preliminary draft of a request for proposal including a possible scope of services, developed by County agencies, was sent to members of the Stormwater Management Task Force for their comments and recommendations. In April 1977, a meeting was held during which Task Force members presented their recommendations on the drafts.

The revised "Request for Proposal" was forwarded to the purchasing agent for recommendation of possible consultants. Six proposals from consultants were received by the Office of Planning and Zoning for a technical evaluation. The Office of Planning and Zoning, Department of Public Works, Soil Conservation Service and Stormwater Management Task Force all reviewed and evaluated the proposals. In June 1977, a written evaluation of each proposal was submitted without recommendation to the Consultant Selection Committee. As a result of the evaluations the County Consultant Selection Committee, composed of the purchasing agent and various department heads, chose the consulting firm of CH2MHill.

In October 1977, the Stormwater Management Task Force met to review the proposed scope of services and contract details. Recommendations resulting from this meeting were discussed with the consultant and a revised contract was signed in January 1978.

Thus, although the final decision for the choice of the Consultant was made by a committee of County department heads, citizens were involved in the consultant selection process from the development of the "Request for Proposal" through the evaluation of the proposals received and into the preparation of the study.

The first meeting with CH2MHill was held in April 1978 to discuss the initial data requirements for work to begin and the format of the study. After the work began, meetings were held every six weeks with the County staff, State agency representatives, CH2MHill and the Citizen Advisory Committee. The purpose of these meetings was to discuss the status of the project and to present new material for review and comment. Besides being vehicles for dissemination of material and information, the meetings frequently evolved into mini planning sessions wherein ideas were presented and discussed concerning specific aspects of the study. These discussions resulted in the incorporation into the study of many citizen generated ideas. The most important was a shift in the emphasis of the study from flooding to stream bank erosion.

As a part of public participation, on July 24, 1978, a field trip within the Severn Run watershed was taken by members of the Citizen Advisory Committee and the Technical Advisory Committee. The trip was conducted for the purpose of acquainting the committees with the problems identified by the consultants during their field surveys. The need for land use planning was also stressed. Land surface erosion and stream bank erosion were identified along with properly and improperly applied control methods.

A public meeting was held on the evening of January 10, 1979, to present an update on the work progress of the study. This meeting was attended by invited citizens, staff members and members of the Stormwater Management Task Force. Background information, slides, and examples of graphics and hydrologic analysis were presented.

The main purposes of this meeting for the consultant were to (1) present identified problems and background information within the watershed, (2) discuss preliminary management techniques and (3) to obtain feedback from the citizens relative to their concerns and observations concerning the watershed.

A three phase review of the final report began in March 1979 with the completion of draft chapters of the more general background information. Copies of these were sent to members of the Citizen Advisory Committee and the Technical Advisory Committee for detailed comments. The second phase included chapters presenting detailed information and results of analysis. The final phase of review included the summary chapters, recommendations and implementation methods. Each group of materials was sent to both committees for review and discussed at a series of meetings.

Certain major changes to the format of the study resulted from this review process. Additional biological data were added to the inventory and an extensive glossary was included. The need for a summary report evolved from the meetings held, and review of this document followed the same review process as it was completed.

The extensive review resulted in a number of revisions in the written text, some of which clarified and corrected portions and others which added new information. Several chapters were combined and new charts and graphs were added. The review process has led to a more readable report and one that is more understandable to the average citizen.

An important revision that evolved from the review was the inclusion of a case study. This study presented an investigation of the effects of proposed commercial development within a section of a subbasin. These developments were simulated to illustrate the principles of watershed management and the roles of government agencies.

Since the Severn Run Watershed Management Study is the first of a series of watershed studies it was felt that this study should provide more background information than would be contained in future studies. Watershed planning is a new concept to the County and in order to facilitate understanding among citizens and County officials, sections such as the case study were included which describe the theories and mechanics of computer hydrology simulation models, methodologies to develop input requirements and various management alternatives available to the County. Recommendations were generally proceeded by a discussion of the pro and con debate which led to their selection.

The Summary Report presents much of the information contained in the main report in a condensed version. The numbers of the tables and figures included remain the same as in the detailed report to aid in locating the detailed descriptions in the main report. Also, major subjects are followed by the chapter numbers that discuss the topic.

Most of the more general background information is eliminated from the Summary Report and the concentration is on the findings and recommendations relative to Severn Run itself and the future of watershed planning in Anne Arundel County.

A number of recommendations relative to structural changes, amendments to County ordinances and regulations, and changes to operating and inspection procedures of various County agencies are contained in the reports. The recognition of an inadequate water quality data base indicated the need for a water sampling and guaging program for Severn Run.

Field visits to the area evidenced a general disregard for the stream and its environment throughout the watershed. A greater public awareness program and a stream-clean-up campaign were recommended. The 208 Program and citizen's organizations such as the Boy and Girl Scouts and Save Our Streams could be instrumental in such an effort.

The final and most important recommendation of the study was for the County to develop an active, full-time multi-agency and representative citizens watershed management program. This program would require close interagency and citizen group cooperation to incorporate watershed management and protection into the daily decision making process.

Having laid the foundation for watershed management, Anne Arundel County must gain strong support from the public for its program. With the base of citizen support already established, by including them throughout the study program, the County expects to gain widespread support as the general public and the decision makers are informed. Upon completion of the final report, the Severn Run Watershed Management Study will be publicized through press releases and wide distribution. To make the report readily available to all interested persons both the Summary Report and the full report will be placed in all County libraries. Copies of the Summary Report will be sent to Civic Associations and special interest groups. Accompanying the Summary Report will be an announcement that the Environmental Resources Section will be available to present the study and to discuss specific details and recommendations.

Proposed Watershed Management Program

As the Severn Run Study neared completion the Office of Planning and Zoning saw the need to develop a methodology whereby watersheds could be effectively prioritized for future studies. The Environmental Resources Section of the Office of Planning and Zoning, in January 1979 assumed the lead in designing a methodology which would evaluate the County's watersheds to determine their criticality for water quality and flooding. In a combined effort County and State agencies, Citizen Advisory Committee members, the Regional Planning Council 208 staff and the consultant of the Severn Run Study designed a scope of work which proposed the development of a Watershed Management Program for Anne Arundel County.

Integral to such a proposed watershed management program is a well organized citizen contingency.

A large network of citizen organizations already exists within the County, whose functions and interests include environmental concerns, community and civic associations, and special interest groups. Many of the smaller community groups belong to large umbrella associations grouped according to geographical areas such as watersheds.

Two such umbrella associations are the Severn River Association and the Magothy River Association. Through representation on the Stormwater Management Task Force, these groups were instrumental in the Stormwater Management Ordinance and the Severn Run Study. Additionally, both of these groups have been active in studying water quality problems within their respective rivers.

The Severn River Association conducted "Operation Clearwater" in 1975-1976, which created a sampling program to monitor the bacteriological quality of the Severn River. The program was intended to supplement the water quality testing done by County and State agencies.

In 1975-1977, the Magothy River Association co-sponsored a study entitled "Effect of Changes in Storm Drain Outfall on Water Quality in the Magothy River". This study evaluated the impacts of general land use patterns in the watersheds of the major fresh water inputs to the Magothy River.

On July 26, 1979, the Magothy River Association sponsored an "Erosion Workshop". This workshop included presentations by the Anne Arundel County departments of Planning and Zoning, Soil Conservation District and Inspections and Permits (Figure 2). Additionally, representatives of the Maryland Department of Natural Resources spoke on the activities of its Water Resources Administration and the "Save Our Streams" program. A field inspection trip was held the following Saturday to various sites in the county to illustrate good and bad erosion practices.

Many of these umbrella organizations have members representing them on other County and State advisory committees, such as the 208 Public Advisory Committee and the Severn River Scenic Rivers Advisory Committee. This creates an integrated network of citizens groups which can be a great asset to watershed programs.

To assure continued public involvement on the part of citizens and to begin implementing the recommendations of the Severn Run Study, the Environmental Resources Section of the Office of Planning and Zoning is proposing the establishment of a permanent Watershed Management Task Force. Its membership would be comprised of technical representatives from the Office of Planning and Zoning, Inspections and Permits, the Department of Public Works, the Health Department, Soil Conservation District, local and regional 208 staff and the Water Resources Administration. Members would also include a permanent group of citizens concerned with watershed management County wide. Additionally, as each watershed is studied, citizen representatives from the watershed under consideration would join the Task Force for the duration of the study.

If established, the Task Force's initial activities will be to: (1) coordinate the implementation of the Severn Run Study recommendations, (2) review the proposed watershed management program for the county and (3) finalize the priority list of watersheds to be studied and select a watershed for the second study. The major citizen input to the development of the watershed management program will be in the definition of program goals, revision of the scope of work and determination of watershed priorities.

Following these initial activities the Task Force will formulate the work program for the second study and develop the "Request for Proposal". The Task Force will play an important role in the determination of the degree of consultant/local staff involvement in the second study.

The Task Force's primary function once the study has begun will be to periodically review work in progress and review and comment on draft reports as they are completed. The Task Force will be responsible for finalizing recommendations and soliciting approval of the

Figure 2. Magothy River Association--Erosion Workshop

PROTECT YOUR RIVER

GET TO KNOW THE FACTS:

Loss of Top Soil From Residential Construction Sites   Sedimentation of Your Streams

EROSION WORKSHOP

WITH SPECIAL PRESENTATIONS BY:

Anne Arundel County Departments of:

- Inspection and Permits
- Soil Conservation District
- Planning and Zoning

Maryland Department of Natural Resources

- Water Resources Adminstration
- SAVE OUR STREAMS Program

Open FREE! to the Concerned Public at the Student Center of Anne Arundel Community College, Thursday evening, July 26th at 7:30 p.m. followed by a Field Inspection Trip, Saturday morning July 28th, at 10 a.m. leaving form the northern end of the Severna Park Shopping Mall on Ritchie Highway at the Goodyear Service Center.

DISCUSSION PERIOD FOR QUESTIONS AND ANSWERS

SPONSORED BY:

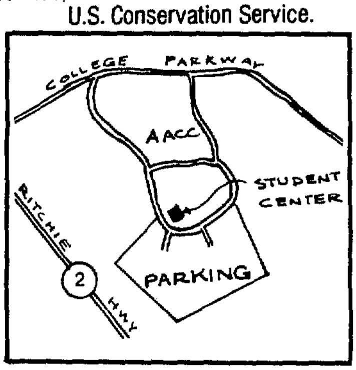
THE MAGOTHY RIVER ASSOCIATION, INC.

1508 Fidelity Building Baltimore, Maryland 21201 Phone 685-7800

TOPICS TO BE COVERED:

Grading and Sediment Planning, Training Program, Control Devices, Standards and Specifications, Legal Requirements, Plus a Slide Show, Evaluation Forms and Reading Lists for further study from The Fish and Wildlife Service, The Environmental Protection Agency and The U.S. Conservation Service.

Anne Arundel Community
College Student Center
July 26th at 7:30 p.m.



MAGOTHY RIVER ASSOCIATION

YOUR MAGOTHY RIVER ASSOCIATION IS CONTINUALLY WORKING FOR YOU!

final plan.

The next task will be to coordinate the implementation of the recommendations from the second study. Upon review of the priority list the next watershed to be studied will be chosen.

In addition to its primary role, the Task Force will have a program of continuing work which may be conducted by sub-committees and/or staff. The Task Force will also assume responsibility for coordinating the Watershed Management Program with ongoing County and State planning activities.

208: A major portion of the 1980 Baltimore Regional 208 program deals with Stormwater Management assessment and program formulation. 208 Staff will be assessing the existing stormwater management program in the County for its interrelationship with water quality and recommending changes in existing programs for improved multiple objective benefits from stormwater management. The formation of the proposed Watershed Management Task Force will potentially offer an integration mechanism between watershed management and 208 planning and assist in meeting Federal requirements for citizen participation in water quality planning.

Sector planning: In September 1977 the County Council adopted a general development plan. This plan calls for the development of a number of sector plans throughout the County. (Sector plans are detailed analyses of small geographical areas.) Watershed management will be an essential element of Sector planning. Also required is the inclusion of stormwater management into sector/watershed plans to insure that land use plans provide the desired results. This will require close cooperation between the Office of Planning and Zoning and the Department of Public Works as well as other County agencies.

Coastal Zone: Coastal Zone policies should be incorporated into future watershed management programs. Watershed management may also be enhanced through future Coastal Zone studies. For example, a study of non tidal wetlands could determine the feasibility of utilizing wetlands to retain storm water.

Sediment and Erosion Control: Future watershed studies could concentrate more effort on studying the control of land surface erosion. Two new erosion models, developed by Colorado State University and the Department of Agriculture, consider particle sizes of sediment. These models should allow investigation of slope controls, buffer strips, mulching, runoff reduction and other preventive controls. A watershed study utilizing these models with soil, rainfall and climatic conditions found with Anne Arundel County could improve evaluation of sediment control alternatives and sediment control plans.

Flood Insurance: The Severn Run Watershed Study delineated the 100 year floodplain and identified residences subject to flooding. This study will be incorporated into a flood insurance study now being conducted by the Maryland Department of Natural Resources.

Another continuing function of the Task Force will be to review proposed zoning changes, subdivision plans and other development plans within watersheds that have been studied and are currently under study.

The Task Force will serve as a focus for "Watchdog" activities within watersheds by monitoring and identifying problem areas and establishing a pipeline for citizen complaints.

In order for the Watershed Management Program to be effective, an active citizens participation/information program needs to be maintained. This maximum citizen involvement will be maintained through various methods such as:

- develop slide/tape presentation (traveling road show available to organizations and schools)
- organize clean-up programs
- develop public workshop programs
- maintain newspaper clipping file and library
- hold field trips
- exhibits for public buildings (County office building, libraries, etc.)
- maintain slide and photo file
- maintain good relationship with media
- develop brochure series describing various aspects of watershed management
- set up a seminar/mini conference
- design and administer surveys
- develop and maintain a monthly newsletter
    - updating work progress
    - listing important meetings and hearings
    - reporting on other planning activities and major developments
    - reporting on pertinent activities of other citizen organizations
    - providing a forum for idea exchanges
        + articles by citizens
        + questionnaires
        + letters to editor

<u>Summary</u>

Although it is too early to determine the full impact of public participation in the County watershed program, (the Anne Arundel County Program being, until recently, in the developmental stage) it is not too early to make certain observations and draw several positive conclusions. The public response to the opportunity to participate in the County's watershed program from its inception has been far stronger than anticipated, both in terms of number of participants and in their enthusiasm and sustained interest. This involvement by the public has resulted not only in a significant number of new ideas and fresh approaches to the various programs encountered, but has occasioned a mutual interest and understanding by both the County and the public of the other's difficulties and points of view. The County, as a result of public participation, has had an unprecedented opportunity to determine the real areas of concern of the public, with regard to watershed management and water quality, and to determine the public's priority with regard to their environment. At the same time, the citizens have shown an appreciation for and understanding of the County's difficulty in developing a program which is both effective and attainable in terms of time, funding and government regulation.

It is believed that public participation will continue at the present high level, and there is every indication that the citizens of Anne Arundel County will be more than enthusiastic in carrying out a watershed--water quality program which they have jointly developed with the County and which they already think of as "their program".

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